AUSTRALIAN ANTARACTIC MAGAZINE 155UE 27 2014



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

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

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ABOUT THE COVER

Australian Antarctic Division Director Dr Tony Fleming took this photo of Adélie penguins on an iceberg during a visit to Commonwealth Bay in 2012.



Advances in remediation science and a developing local expertise have allowed Australian scientists and engineers to begin addressing long-term soil contamination issues at Australia's Antarctic and subantarctic stations.

Since 2003, remediation teams have applied and modified existing remediation technologies, normally used under warmer, more favourable conditions, to clean up fuel spills and develop risk and remediation guidelines for Australia's Antarctic and subantarctic stations and environments. The work will be used to assist other Antarctic nations in their remediation efforts and to tackle legacy sites such as Australia's abandoned Wilkes station.

At Casey station, members of the Australian Antarctic Division's remediation team have delivered a significant and ongoing decrease in soil contamination at the station over the past four years. The first stage of the Casey clean-up began in 2005, to deal with a 6000 litre fuel spill at the station's main powerhouse in 1999. The remediation team, in collaboration with scientists from the University of Melbourne, installed a 'permeable reactive barrier' (PRB) at the site. These barriers prevent fuelcontaminated snowmelt and groundwater from leaching into the surrounding environment, by channelling it through a treatment system. 'PRBs are the first step in a multi-step process used to treat a contaminated site,' Australian Antarctic Division Remediation Specialist, Mr Tim Spedding, said.

'PRBs contain the effects of a spill and minimise the spread of contamination until the site can be more actively remediated. You need to install them first because once you start excavating contaminated soil for treatment you'll also thaw the ground and remobilise a lot of the contaminants in the meltwater.'

The PRB consists of a series of cage pallets containing pelletised nutrients and activated carbon, which is placed in the path of the meltwater flow. When the water enters the barrier it becomes enriched with nutrients, which stimulates the native soil microbes to begin degrading fuel captured on the activated carbon. After a further nutrient capture step, clean water flows out the other side of the barrier.

In Antarctica the environmental conditions are such that PRBs can only passively treat contaminated meltwater, rather than actively reduce soil contamination. So in 2010 the team embarked on an active approach to remediation by excavating the contaminated soil and creating a series of 'biopiles'. Like PRBs, biopiles use the native soil microorganisms to break down fuel contaminants. They do so at a faster rate, however, because the soil conditions are optimised for microbial growth by the addition of air and moisture.

Over three summer seasons, seven biopiles have been built at Casey station, with each soil pile measuring some 18 x 5 m in size and 1.5 m high. The biopiles are active for up to three months a year, when summer temperatures are high enough to thaw the soil and release moisture. Once the soil is thawed, leachate water is re-circulated through it to increase soil moisture distribution. A system of aeration pipes forces air through the biopiles towards a carbon filter at one end, trapping any volatile compounds that then biodegrade or evaporate.

 Remediation at the Main Power House fuel spill site. Contaminated soil is being excavated in front of the permeable reactive barrier (lower right of photo) and placed into biopile 6. Biopiles 1-5 can be seen with their covers on. Aeration systems are visible between the biopiles.

SCIENCE

While the technology has been used extensively in the Arctic and temperate environments, Antarctica has different environmental conditions and soil types. As a result, the team has had to research and tweak their materials and methods while they work. Part of this process involved testing a variety of materials used to cover and to line the base of the biopiles. To do this, the remediation team recruited geoenvironmental engineer Dr Rebecca McWatters, from Queen's University, Canada, for her expertise in Arctic contaminated sites, geosynthetic materials and barrier systems.

'For the past three years we've been investigating different combinations of geosynthetic liner materials on the biopiles, to test their long-term performance as a composite barrier system in preventing the movement of contaminants out of the biopiles and into the environment; all while the soil was being treated,' Dr McWatters said.

'We've also trialled a range of geotextile covers, which prevent contaminated dust being blown off the biopiles.

'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 lifespan of the contaminated soil.'

The tests were conducted on the biopiles while soil remediation was underway, but also in a variety of other field- and laboratory-based tests. By early 2014 the team had supportive evidence for a combination of materials that would do the job while withstanding the cold, dry, windy, abrasive and UV-intense environment. In the process, the team also significantly remediated the contaminated soil. 'Our most recent tests show that hydrocarbon concentrations in the biopiles are decreasing by 50% every 500 days,' Dr McWatters said.

'This compares to no detectable change over five years when just the PRB technology was used to contain the contaminants on site. This is very exciting and shows we are nearing our goal of returning remediated soil to the Casey environment for specific reuse applications.'

But how clean is clean enough? That is the question now occupying the remediation team and ecotoxicologists at the Australian Antarctic Division (see side bar). While the soil will never return to its original state, there will be a point beyond which the effort to continue remediation will be disproportionate to the risks posed to the environment's flora and fauna.

- 2. During construction of biopile 6, a geotextile is rolled out over a protective soil layer and the PVC pipes of the aeration system.
- Some of the remediation team members: Melbourne University collaborator Fiona Fry (left) and the Australian Antarctic Division's Greg Hince, Rebecca McWatters and Johan Mets. Other members of the Antarctic Division remediation team include Lauren Wise, Dan Wilkins, Deborah Terry, Scott Stark and Greg Lagerewskij.
- 4. Members of the remediation team take samples from one of the permeable reactive barriers (PRBs) at the site. PRBs are the first step in treating a contaminated site, used to minimise the spread of contamination before active remediation techniques are employed.
- 5. Antarctic mosses (a) *Schistidium antarctici*, (b) *Bryum pseudotriquetrum*, (c) Ceratodon purpureus, and the Antarctic terrestrial alga (d) *Prasiola crispa* following 28 days of exposure in control soils (no fuel) (top row) and in soils spiked with Special Antarctic Blend fuel (61 800 mg/kg soil) (bottom row).
- 6. The springtail *Hypogastrura viatica* is a potential ecotoxicology test species.







While the ecotoxicology work is still in progress, Mr Spedding said the remediation team has enough scientifically sound remediation options and technical expertise to begin to address clean-up issues at more difficult sites.

'And through the Antarctic Treaty system we'll be able to pass on what we've learned to other nations, so that they can apply it without having to go through the lengthy tests and trials we've already undertaken,' he said.

WENDY PYPER

Corporate Communications, Australian Antarctic Division





How clean is clean enough?

How clean should contaminated soil be to protect its ecological function and value? That is the question Australian Antarctic Division ecotoxicologist Dr Catherine King and her team will answer as they develop remediation targets for contaminated sites in Antarctica.

The team is currently working with the Casey station remediation team (see main story) to develop targets based on ecotoxicity testing for a range of native Antarctic organisms.

The team has used similar methods on Macquarie Island to establish interim remediation targets for fuel contaminants in the subantarctic.

The Antarctic targets will eventually inform clean-up manuals that can also be used by other Antarctic nations dealing with their own contamination and remediation issues.

'We're aiming to identify fuel concentrations that, on average, would protect say 80% of the biological function of a disturbed site, such as occurs around a station, or 95% for a pristine site,' Dr King said.

'So the targets will depend on the land use and the values of the land. But even if you get back to 80%, that's still a well-functioning ecosystem.'

Remediation in Antarctica, however, poses more of a challenge than the subantarctic.

'Antarctic soils have the same diverse microbial communities that you'd expect worldwide,

but they have few microinvertebrates, no macroinvertebrates and they have very few plants — only mosses, lichens and algae,' Dr King said.

'So we just don't have the biological diversity and the organisms that you would typically use for ecotoxicology experiments, like flowering plants or grasses for seed germination tests, or macroinvertebrates for survival and reproductive tests.'

Instead, the team will focus more on developing toxicity tests with Antarctic mosses and terrestrial algae, and with two Antarctic microinvertebrates — nematode worms and springtails. They will also study the soil microbial communities and their functioning using bacterial genes to identify changes in species richness and diversity.

The results from the ecotoxicology work will be used to develop robust remediation targets to inform the Casey remediation team when they can return the biopile soil to the station for reuse. The work will also provide 'trigger values' that will allow Australia and other countries to prioritise sites for clean up in the future.

'The trigger values will allow us to determine the risks posed by a site, so that, on an international scale, if we have say 50 sites to clean up across Antarctica, we can make an informed decision about how to prioritise them,' Dr King said. WENDY PYPER



Future ocean in a chamber

Australian scientists will create a 'future ocean' under the sea ice off Casey this summer, using four underwater chambers to measure the impact of ocean acidification on seafloor ('benthic') communities.

Ocean acidification is caused by increasing amounts of atmospheric carbon dioxide (CO₂) dissolving into seawater. This causes the pH of the seawater to drop and become more acidic, which affects the ability of some marine organisms, including corals, bivalves and some phytoplankton, to form shells and other hard structures. It also disrupts other important physiological processes (see fact box).

The four semi-enclosed chambers will be deployed on the seafloor, 10 to 20 m beneath the Antarctic sea ice off Casey station, between November 2014 and March 2015.

During the Antarctic 'Free Ocean Carbon Enrichment' (antFOCE) experiment, a team of scientific divers, technicians and engineers, will increase CO₂ concentrations in the water in two of the chambers. This will decrease the pH of the water (by 0.4 pH units), without changing light or nutrient concentrations. A further two chambers will be used as 'controls' to track natural fluctuations in pH in the surrounding water. This will allow the team to compare the response of benthic communities exposed to current seawater pH levels, and the more acidic pH levels predicted under future CO₂ emission scenarios. A variety of observations and measurements will be made to allow the team to determine how benthic marine habitats respond to decreased seawater pH. These include:

- changes in benthic invertebrate community biodiversity and composition in sediments and on hard substrata;
- seawater carbonate chemistry;
- nutrient cycling in sediment;
- changes in communities of bacteria, diatoms (single celled marine plants) and sediment 'meiofauna' (very tiny critters);
- 'bioturbation' how the actions of animals mixes the sediment; and
- 'primary production' the growth of marine plants such as diatoms.

The research will assist governments, scientists, modellers and society to understand the emerging impact of ocean acidification on marine ecosystems and to ensure that the most relevant information underpins decisions to manage the threat.

Pumping gas

The underwater chambers used in the Antarctic Free Ocean CO₂ Enrichment experiment are adapted from a prototype developed by the Monterey Bay Aquarium Research Institute in California. To date, this technology has been deployed in experiments run at sites in deep and shallow temperate waters and in shallow tropical and sub-tropical waters. As a result, the Australian Antarctic Division team has had to adapt the design and deployment of the chambers for the harsh Antarctic conditions.

Earlier this year the team spent several weeks testing the chambers in cold water off the coast of Tasmania, to practice deploying them and ironing out as many glitches in their operation as possible.

The Antarctic chambers are each coffee tablesized acrylic chambers (2 m x 0.5 m x 0.5 m) anchored to the sea floor and sufficiently robust enough to withstand the -1.8° C water temperature. A series of pipes, linked to pumps, draw seawater to the surface, where it is enriched with CO₂, before being pumped back down under the sea ice and into the two experimental chambers. This provides a constant flow of CO₂ -enriched, low pH seawater, through the two chambers.





What is ocean acidification?

- When CO₂ dissolves from the atmosphere into the ocean it increases the acidity of the ocean.
- Cold water is able to absorb more CO₂ than warmer water. As a result, polar waters are acidifying at twice the rate of tropical waters.
- The Southern Ocean absorbs 40% of the global ocean uptake of CO₂.
- Changes in acidity is measured on a pH scale. pH 7 is neutral, while a range between 0 and 7 is considered acidic and between 7 and 14 is alkaline. While the ocean pH is currently above pH 8, it is gradually decreasing.
- Ocean acidification disrupts the formation of calcium carbonate (CaCO₃), which is a major structural component of shells and similar hard structures made by some marine organisms, including phytoplankton and coral.
- Ocean acidification also affects the metabolic and physiological processes inside organisms including development, growth, reproduction and respiration.
- Ocean acidification will result in both winners and losers in future oceans. Some marine algae are expected to benefit from ocean acidification but most calcifying organisms are expected to suffer.
- The Intergovernmental Panel on Climate Change found that since pre-industrial times there has been an average decrease in ocean pH of 0.1 unit.
- Under a 'business as usual' CO₂ emissions scenario, ocean pH is projected to decrease by another 0.3 to 0.4 units by 2100.
- Current atmospheric CO₂ concentrations are about 416 parts per million (ppm), while ocean pH is about 8.1. By 2100 under 'business as usual' emissions, atmospheric CO₂ is predicted to be about 936 ppm and ocean pH 7.8.
- The Antarctic research team will run their CO₂-enriched chambers at 0.4 pH units below the current naturally fluctuating pH of the waters off Casey station.



Sample water drawn up from the experimental and control chambers passes through a series of pH, conductivity, temperature and oxygen sensors in the 'Silver Chalet' – a small shore-based control centre above the sea ice. Underwater flow meters, thrusters, pH and temperature sensors are all powered from this surface hub.

Data collected from loggers in the Silver Chalet is wirelessly relayed back to station, allowing the technical team to monitor the experiment's progress when no-one is on site. Last but not least, time-lapse cameras mounted on top of the chambers record how the structure of surface sediments in the chambers is changing over time.

Sea ice and 'fast' ice (attached to land) pose one of the biggest challenges to the success of the project. As there's a reasonable tidal range at Casey, for the duration of the experiment there will be a few metres of sea ice grinding against the shore, bringing one tonne of force per cubic metre of sea ice.

To avoid this problematic zone, the project's technical team has developed an original solution. Water pipes and power and data communication cables will be bundled together into an 'umbilical'.

This umbilical will extend from the shore-based control units and pass over the tide cracks, where sea ice meets and rubs up against the fast ice. They will then run under the sea ice through a pipe running down the middle of a sea ice buoy. This sea ice buoy (or 'smartie') will sit in a 90 cm wide hole drilled through the ice. In this way the team hopes to cleanly and safely transition between under-ice and shore-based infrastructure, avoiding the problems of tidal flux and moving sea ice.

Another unique addition to the experiment is the use of two mini chambers, which can be attached to the main chambers for 24–48 hours, to run short-term experiments on individual organisms (such as a sea urchin) or to measure the effects of ocean acidification on photosynthesis. These experiments will demonstrate the potential long-term effects of ocean acidification (over 4 months) and will allow the project team to understand some of the short-term responses and acclimatization of organisms to ocean acidification.

GLENN JOHNSTONE¹ and JONNY STARK² ¹ antFOCE Project Manager, Australian Antarctic Division ² antFOCE Chief Investigator, Australian Antarctic Division





 O'Brien Bay at Casey – the site where the chambers will be deployed.

- 2. The sea floor in the waters off Casey where the chambers will be deployed.
- 3. One of the chambers attached to the thruster tube and yellow ducting that will carry regular or CO₂ -enriched seawater into the chamber.
- 4. A cutaway diagram of the sea ice buoy or 'smartie' showing how the communication and power cables will run from the surface of the sea ice to the underwater chambers.
- A diver tests one of the chambers in the cold waters of Tasmania before deployment in Antarctica.
- 6. Diagram showing how the antFOCE system is put together.

Navy survey identifies new seabed features at Casey

Navy surveyors using the latest multi-beam echo sounding technology over the seabed at Casey have identified underwater features that reveal the past extent of the Antarctic continental ice sheet.

For some 30 years the Royal Australian Navy's Hydrographic Survey Branch, with the support of the Australian Antarctic Division, has conducted numerous seabed surveys in Antarctica and the subantarctic. These surveys have primarily mapped the approaches to Australia's four permanent research stations.

With the exception of a collaborative activity involving Geoscience Australia at Davis in 2009–10, all of this survey work has been conducted using outdated single beam echo sounders. Although these sonars are useful in collecting depth information and producing nautical charts, they are unable to provide detailed representations of the seabed. This limitation prevents the discovery of all potential hazards to surface navigation and restricts the utility of the data to scientific research.

In 2013–14 a group of four hydrographic surveyors and one marine technician from the Navy's Deployable Geospatial Support Team deployed to Casey on the RSV *Aurora Australis*. The team was tasked with conducting a hydrographic survey of Newcomb Bay and O'Brien Bay. This marked the first occasion for almost a decade that a naval vessel had been part of the Australian Antarctic program.

Although the Navy's vessel Wyatt Earp has previously operated in Antarctica and at Macquarie Island, this was its first deployment since a refurbishment and the installation of a new multibeam echo sounder that can provide high resolution depictions of the sea floor. Trialling this new sonar was an important component of the year's activity and the quality of the data produced, together with its immediate relevance to some of Australia's Antarctic science projects, was very pleasing. The use of this data to support research activities was a new frontier for Navy surveyors, who primarily collect data for charting and military use. Because of this, the survey at Casey represented a significant cognitive leap forward, which was nicely complemented by the technological leap offered by the new sonar.

The images generated by the multibeam sonar showed an incredibly dynamic sea floor. Particularly striking features were large crescent shaped 'moraines' (piles of glacial detritus), created during pauses in past ice sheet retreat (see side bar for more detail). The moraines mark where the ice sheet grounding-zone (the point where the ice-sheet meets the sea floor) remained long enough to melt and drop gravel and rock debris that had previously been frozen in to the base of the ice sheet. Although hundreds of metres long, these features were previously unknown from Casey, being too large for divers to recognise them for what they are.

Australian Antarctic Division science program leader, Dr Martin Riddle, first attempted to map seabed habitats at Casey in 1997, but the acoustic technology available at that time was unsuitable. While at Casey for another science project in 2013, Dr Riddle was on hand to receive daily progress reports. His obvious excitement was very gratifying and spurred the team on to cover as much ground as possible.

According to Dr Riddle the multibeam data is essential for understanding the nature and scales of natural environmental variability, so that scientists can identify the subtle signals of environmental change caused by human activity.

RAN/GEOSCIENCE AUSTRALI

Seabed structure in detail

High resolution sonar imagery of the shallow water environs around Casey station has revealed seabed features in Newcomb and O'Brien bays in unprecedented detail, providing geoscientists with tantalising glimpses into the glacio-geomorphological evolution of the seabed.

The extent of the vast continental Antarctic ice sheet during, and since, the Last Glacial Maximum some 20 000 years ago is not well understood. The features imaged on the seabed at Casey may contribute to a better understanding of past glacial expansion and retreat of the East Antarctic ice sheet.

The seabed features are characterised by complex and often cryptic morphology and likely formed when the ice sheet locally extended seaward beyond its present limits. In O'Brien Bay and the north side of Newcomb Bay, curved seabed features resemble end 'moraines' (piles of glacial detritus) of channelized outlet glaciers, deposited as the glaciers episodically retreated. The channels in Newcomb and O'Brien bays are some 200–400 m wide and preserve U-shaped profiles (see Figure 1), characteristic of glacially eroded valleys seen on land.

One large moraine, labelled 'a' in Figure 1, is particularly well developed, and up to 25 m high. Many smaller moraines, about 5–10 m high, are also easily discernible. In O'Brien Bay there is evidence of at least two generations of moraine formation, indicating local glacial advances overprinting earlier moraines. Other features include parallel linear features ('b' in Figure 1), discontinuous shallow channels around 3–5 m wide ('c') and enigmatic crescent-shaped hollows or scours ('d'). These features may have formed beneath a slower moving ice sheet in contrast to the adjacent channelized, faster moving, outlet glacier in northern Newcomb Bay. In 2014–15, geoscientists and hydrographers from the Australian Antarctic Division, Geoscience Australia and Royal Australian Navy will collect more extensive sonar data in the Casey region, as well as seabed samples and photography. The work will help us better understand these intriguing seabed glacial features, including their age, how far they extend seaward and their physical composition.

CHRIS CARSON and JODIE SMITH Geoscience Australia, Geocat 82324

Figure 1



A three dimensional representation of the seabed features in Newcomb Bay (see boxed area in image below). Note the series of probable end moraine features on the channel floor. The profile (X X') shown in the upper left is taken across the channel immediately behind moraine 'a', illustrating the typical U-shaped valley profile of glacially eroded channels. The labelled features (a–d) refer to the text. (View looking to the north-east).



- The Navy's hydrographic survey team at Casey.
- 2. Unprocessed data from the multibeam echosounder used over Newcomb Bay. Crescent-shaped moraines can be seen throughout the bay. The black box delineates the area of the channel and other seabed features described in Figure 1 above. The red peak in the centre of the box is the peak marked X' in Figure 1.





Until now, knowledge of coastal seabed ecosystems in the Casey region has been limited to the tiny snapshots of information gained by divers. The new multibeam data will allow scientists to join up the detailed information from the few places scientific teams have dived, and build a picture of the whole coastal area.

Our survey at Casey was interrupted by the requirement to assist a stricken Russian vessel trapped in ice near Commonwealth Bay. The multinational effort to rescue the passengers was a well timed reminder of the remoteness and scale of the Antarctic continent and the challenges faced when responding to an incident at sea. As the number of vessels transiting the Antarctic increases, the importance of improved charting will continue to rise.

The lack of adequate charting poses a significant threat to shipping in an environment where the consequences of any incident will likely be catastrophic. The International Hydrographic Organization has established the Hydrographic Commission on the Antarctic to encourage survey activities in the Antarctic and to coordinate an international charting scheme.

- 3. The Royal Australian Navy's hydrographic survey vessel, *Wyatt Earp*, at Casey.
- 4. Crescent-shaped moraines can be clearly seen in the blue coloured echosounder data of O'Brien Bay. These features mark grounding-zone lines created in the past as the advancing ice-sheet pushed the sea-floor into mounds.

However, very large areas remain to be adequately surveyed and the task of improving the safety of Antarctic navigation is daunting.

During the six days of survey operations at Casey the team faced unique challenges; some expected, others not. It is hoped that the lessons learnt from these challenges will provide a firm foundation for the continued growth of the program in the years ahead. It is also hoped that further collaboration with the Antarctic Division and Geoscience Australia will provide a strong basis for detailed planning to ensure outcomes are reached that serve the needs of both science and the safety of navigation. For Navy personnel accustomed to only interacting with other members of the Australian Defence Force, this collaboration was a highlight, as was the opportunity to witness the operations of the Antarctic Division and P&O Shipping in an extremely difficult yet spectacular environment.

LIEUTENANT PETER WARING

Deployable Geospatial Support Team

Antarctic marine hotspots identified by animal tracking

Satellite tracking of seal and seabird species in the East Antarctic sector of the Southern Ocean has identified six areas of marine habitat important to multiple species.



The research, published in *Ecography* in July, demonstrates a way of identifying marine areas likely to be of ecological significance, which can be used for conservation planning and management activities, ecosystem modelling, and to assess future changes in habitat use.

Computational ecologist Dr Ben Raymond, from the Australian Antarctic Division, said most satellite tracking ('telemetry') studies have been conducted on individual species and few have been able to consider multiple species at once.

'Combining telemetry data from a diverse suite of Antarctic marine predators has allowed us to identify several marine regions and features important to these animals,' Dr Raymond said. 'These include regions accessible to breeding colonies, and winter polynyas – areas of open water that are often associated with increased prey availability.'

The study used two decades of telemetry data collected by Australian and French Antarctic research teams for Adélie and emperor penguins, light-mantled albatrosses, Antarctic fur seals, southern elephant seals and Weddell seals.

The preferred habitat of each species was identified by applying statistical modelling methods to the observed tracks. Each species model was then used to predict the habitat preference for that species over the entire region of interest.



When the team combined the results from the individual species, they found a high degree of overlap in six regions. The favoured regions were generally close to Antarctic and subantarctic breeding colonies, and winter polynya areas that are known to be highly productive and which provide diving predators with access to under-ice prey.

'Areas of overlap were all located in the southern part of the study region, generally over the Antarctic shelf and waters immediately to its north, excluding deep, open oceanic areas,' Dr Raymond said.

The results were consistent with previous studies which have shown, for example, that both Adélie and emperor penguins prefer habitat close to their breeding colonies during the chick-rearing period. Light-mantled albatrosses prefer offshore areas, closer to their subantarctic breeding islands. Male and female southern elephant seals, in contrast, disperse widely from their colonies after breeding and concentrate on shallow parts of the continental shelf and areas of winter polynyas.

The study authors said their research, and similar research programs tracking multiple species, were important for Southern Ocean conservation planning efforts. This includes the establishment of marine protected areas currently being considered by the Commission for the Conservation of Antarctic Marine Living Resources.

WENDY PYPER

Corporate Communications, Australian Antarctic Division



New ice core records rewrite volcanic history

The Earth's volcanic history has been rewritten thanks to a new and more extensive array of Antarctic ice cores containing detailed eruption records.

The findings will permit more stringent tests of models against past climate variations. This will help reduce uncertainties in model projections for the future, which are used to inform climate policy decisions.

The research was conducted by an international team of scientists led by Dr Michael Sigl from the Desert Research Institute (USA) and including Dr Mark Curran from the Australian Antarctic Division. The team measured sulphate aerosols – a by-product of volcanic eruptions – in 26 ice cores taken from 19 different sites across Antarctica.

From these aerosol measurements the team identified 116 eruptions over the past 2000 years and obtained the most accurate estimate yet of the eruptions' strength and timing.

'We've developed a more accurate picture of volcanic activity by looking at the amount of sulphate aerosols deposited in a much larger number of ice core samples than were previously available,' Dr Curran said.

'These cores included some with highly detailed and well dated records, such as the core Australia collected from Law Dome in 1993, and this allowed us to better synchronise the cores and ensure that common events were correctly dated.' Volcanic eruptions spew large amounts of sulphur dioxide into the atmosphere, where it converts to sulphate aerosols. These aerosols deflect sunlight away from the Earth's surface leading to shortterm global-scale cooling. Bigger eruptions result in more sulphate aerosols and therefore more 'forcing' of the climate towards cooling.

Leader of the Australian Antarctic Division's climate program, Dr Tas van Ommen, said this forcing effect is used in climate models to simulate the climate of the past, and provides a test for determining the sensitivity of the climate system to natural and man-made climate forcing.

'Part of the uncertainty in future climate projections comes from model-to-model variability,' Dr van Ommen said.

'The ability to test models against past changes allows us to evaluate which ones do a better job, and provide the best basis for policy decisions.' Prior to this study, estimates of volcanic forcing were measured in a smaller number of ice cores taken from low snowfall sites. Low snowfall causes irregular snow accumulation patterns and, as a result, uncertainty in sulphate aerosol deposition estimates. Also, as aerosol deposition in ice is not uniform across Antarctica, a wide array of ice cores is needed to get a representative and more accurate measure of volcanic fallout. 'We had very few good ice core records extending prior to 1500,' Dr van Ommen said.

'Tree ring records pointed to global-scale volcanic events that would have had a pronounced impact on climate, but we had difficulty identifying these in ice cores, particularly during the first 1000 years AD.'

After adding many new records and correctly dating older records, and then comparing them to the best annually dated 2000 year ice cores, the team found that the existing volcanic reconstruction after 1500 was excellent, but substantially different prior to this time. Global aerosol forcing from some of the largest eruptions prior to 1500 were overestimated by 20–30% and others underestimated by 20–50%.

Aerosol loads in the ice cores showed that the largest eruptions occurred in Indonesia in 1257 (Samalas) and 1815 (Tambora) and in Vanuatu in 1458 (Kuwae). In the first millennium three smaller but significant eruptions of unknown origin occurred in 531, 566 and 674.

'Our research allowed us to re-date the Kuwae eruption from 1452 to 1458, and we also found that the Samalas and Kuwae eruptions were less intense than previously estimated, translating to 15% and 25% less global aerosol loading respectively,' Dr Curran said.

'This explains in part a mismatch of temperature reconstructions and climate simulations for these events.'

While further work is needed to identify climatically important eruptions in the northern hemisphere that affected the southern hemisphere, the research team said the current study provides a 'step-change' improvement in existing reconstructions of volcanic aerosol loading for the southern hemisphere.

WENDY PYPER

Corporate Communications, Australian Antarctic Division

^{1.} Mt Erebus on Ross Island, is the most active volcano in Antarctica.



Keys to a hidden marine world

An online tool, capturing the intricate structures of hundreds of microscopic Antarctic marine plants and animals, is helping scientists identify these important organisms.

They are works of art on a microscopic scale – perfectly formed, single-celled Antarctic marine plants and animals. Some look like dimpled water jugs, others like cricket balls, roughly woven baskets, or six-pointed stars.

These cells (which together are called 'protists') range in size from one micron (one thousandth of a millimetre) to four millimetres in length. But their small size belies their importance. Protists sit at the base of the marine food web and their vast numbers support the wealth of life for which Antarctica is renowned. They also alter concentrations of gases in the atmosphere that affect global climate, and are responsible for much of the oxygen we breathe.

Now, highly detailed images of more than 600 of these microscopic plants and animals feature in a collection of interactive 'taxonomic' (identification) keys, developed by Australian Antarctic Division scientists Dr Fiona Scott and Dr Imojen Pearce. The keys fill a gap in modern protist identification and have already attracted both national and international interest.

The online keys allow Antarctic biologists to classify protists within 12 taxonomic groups. Classifying such organisms is vital if we are to detect the effects of environmental change on their distribution and abundance, and to predict the possible future for life in Antarctic waters. Any climate-induced change in their composition, abundance and activity in the Southern Ocean is likely to have far-reaching consequences for marine food webs, wildlife conservation and fisheries productivity, and will feed back to affect rates of climate change.

As the numbers of scientists with the knowledge to identify organisms using their physical features are in decline, these new interactive keys make the specialist knowledge and skills required to identify Antarctic marine protists available to all. The information and images used in the keys are mainly sourced from the book *Antarctic Marine Protists*, published jointly by the Australian Antarctic Division and the Australian Biological Resources Study in 2005. The book synthesises decades of research in the Antarctic and subantarctic regions by Australian and international scientists, and describes and illustrates the diagnostic features of each protist recorded.

These diagnostic features drive the interactive keys, by allowing biologists to select multiple features of a cell, based on what they can see in their own sample. The keys contain over 2000 electron micrographs, light micrographs and line drawings, which record the intricate details of each organism. Biologists can either match their specimen to an image in the keys, or work through a checklist of features, such as the presence or absence of physical structures, and cell size and shape. This offers a faster and more powerful method than using traditional paperbased dichotomous keys or pictorial guides.

The sheer diversity of marine protists means the identity of some organisms remains unknown to science. To accommodate this, the keys include two groups containing images of cells of 'unknown' or 'uncertain' classification, with an invitation for users to contribute data and images to address these knowledge gaps.

Each organism in the keys is linked to a fact sheet that details its distribution, where it was first recorded and by whom, its physical attributes, and references. There is even scope to include genetic information about each species in the future. The keys also include recent new discoveries, taxonomic revisions and many updated images not contained in the book. Importantly, the keys can operate from a CD or flash-drive, so that they can be used offline, onboard ships or in Antarctica.

The Antarctic Marine Protists keys are available at taxonomic.aad.gov.au.

FIONA SCOTT and ANDREW DAVIDSON Science Branch, Australian Antarctic Division





- Dinophysis ovum; one of 82 species of dinoflagellates described in the key. Dinoflagellates have two whip-like 'flagella' which allow them to move in a whirling motion. The cells are large enough that they can be identified by light microscopy, but scanning electron microscopy may be needed to resolve some features.
- This single-celled phytoplankton species *Pyramimonas gelidicola* has four flagella and is covered with minute organic scales.

Antarctic lakes are full of small surprises



- 1. Sarah (right) and Alyce drill for water samples on an Antarctic lake.
- Sarah is spending 17 months in Antarctica (October 2013 – March 2015) studying microbial communities in aquatic ecosystems.
- 3. Organic Lake in the Vestfold Hills near Davis station harbours one of only a handful of virophages discovered in the world. As about 85% of life on Earth lives in environments colder than 5°C, studying microbes in Antarctica provides an insight into life on other parts of the planet, as well as the types of life that could exist on other planets.
- 4. The Organic Lake Virophage identified by the UNSW team in after lake sampling in 2008. The virophage attacks viruses that infiltrate other cells such as algae or bacteria. See Australian Antarctic Magazine 20: 10, 2011 for details.

Sarah Payne and Alyce Hancock are part way through a 17 month posting to Antarctica to study changes in the microbial communities living in the lakes near Davis station. The University of New South Wales (UNSW) scientists are part of Professor Rick Cavicchioli's team, whose work at the lakes has recently featured in this magazine (Issue 25: 12-13, 2013). Here Sarah gives an insight into their research so far.

Alyce and I are taking samples from three lakes and an ocean site to study the microorganisms present in Antarctic aquatic systems. Most of the samples we take will be used to determine what changes take place in the microbial communities throughout an entire Antarctic year. Other samples will be used to discover what microbes are present in a range of lakes that have never been studied before. Building upon previous discoveries by Professor Rick Cavicchioli's group, the work we are doing will help to determine:

- which microbes are present;
- why they are present;
- if they are common or unique;
- what functions they perform in the environment;
- how they perform their functions;
- how much the microbial communities and functions change throughout the seasons and across the years; and
- what impact human activities and global ecosystem changes will have on Antarctic aquatic systems.

Because microbes are the beginning of the food chain and carry out critical processes in nutrient cycling that no other life-forms can perform, it is important that we study them. Also, about 85% of life on Earth exists in the cold (i.e. below 5°C), so learning about microbes in Antarctica not only informs us about life in this wonderful, pristine environment, but has broad implications for much of life on the planet.

I have learnt many surprising things so far. For example, the lakes we study were part of the ocean about 5000 years ago, so in essence we are learning how marine life has evolved to what we see now – there are hundreds of lakes and they are each unique 'time capsules'.





Ace Lake, Organic Lake and Deep Lake, near Davis station, are the lakes we take most of our samples from, and each is very different.

Ace Lake has two distinct layers, an aerobic (contains oxygen) top, and anaerobic (no oxygen) bottom full of methane and hydrogen sulphide. Unique light-harvesting microbes, called green sulphur bacteria, grow right between these two layers in the lake and are critical for the nutrient cycling of the whole lake ecosystem.

The surface of Deep Lake sits 55 m below sea level, and has a very high salt concentration. The temperature of the lake can drop to -20°C but it does not freeze because it is hypersaline a bit like a very, very cold, Dead Sea. The lake is a real mystery because it contains 'haloarchaea', which are very promiscuous and readily exchange DNA with one another.

Organic Lake is also quite salty, but it contains a special virus called a 'virophage' which is actually a predator of a larger algal virus. The virophage is believed to benefit the microbial community in the lake by promoting algal growth cycles during summer. Since the discovery of the Organic Lake Virophage, these special viruses have also been found to be present in diverse aquatic systems around the planet.

The research we are part of shows just how surprising and unpredictable discoveries about Antarctic microbes can be, and also just how important the discoveries are for understanding life on Earth more broadly (see side bar).

Our days are split between working in the laboratory, preparing for field trips, and being out on the lakes collecting the samples. A typical day for us can vary from being in the lab counting microbes under the microscope, to being out on a lake drilling through a metre of ice to collect water, trying to prevent it from freezing long enough to take our samples in air temperatures between -10°C and -30°C. This is my third trip to Antarctica with the Australian Antarctic Division, but the first time I have stayed over winter. My first trip was in October 2010 when I spent five months at Davis station studying ecotoxicology on marine plankton. I returned to Davis in December 2012 for two months in a similar role.

The most surprising thing I have found over winter is just how devoid of life this vast continent

Extremophiles on and beyond Earth

From a human perspective, the Antarctic environment is rather extreme. Because we view life on Earth and life beyond Earth through human eyes, gaining a perspective about what environments sustain life on Earth also enhances our view of where we might want to look for extraterrestrial life.

For example, methanogens are microbes that produce methane, and all biological methane on Earth is produced by these 'archaea'. They live in surprising places like rice fields, wetlands, and also in cows' stomachs and are responsible for all the methane ruminant animals belch out and release to the atmosphere as a powerful greenhouse gas. But some methanogens also grow deep in the ocean in hydrothermal vents and will grow in the laboratory in an autoclave at 122°C. Yet again, other methanogens grow in Antarctica (see main story) — they have been so active in the bottom of Ace Lake that the waters are saturated in methane!

Interestingly, some methanogens don't need organic (biological) matter for growth. They can grow using totally inorganic compounds like hydrogen and carbon dioxide for generating energy and for carbon (needed for cell growth), and using ammonia for nitrogen (also needed for cell growth). In the process, they produce biological matter themselves. Because they grow without oxygen, they are perfect examples of the types of microbes that could be growing right now on Mars, or on the Jupiter moon, Europa. becomes. During the summer there are many seals, seabirds and penguins, but once the last of these head north for the winter it becomes very quiet. On a windless day out in the field, if I stand still and listen, there is absolutely no sound or movement, and I feel like I could be the only living thing on the continent (except for the microbes of course). SARAH PAYNE

UNSW



Because there is evidence that water exists on Mars (a requirement for life as we know it), plus methane is produced and exists now in the Martian 'atmosphere', it could be that Earth-like methanogens grow there and produce Martian methane. Similarly, Jupiter's moon Europa has subsurface water, so cold-adapted methanogens, similar to those we find in Antarctic lakes, could be growing there.

This is just one example of how studies of 'extremophiles', and particularly Antarctic extremophiles, provide us with clues about possible forms of extraterrestrial life and where to look for such life.

RICK CAVICCHIOLI

School of Biotechnology and Biomolecular Sciences, UNSW

Instant sinking hooks will save seabirds in tuna longline fisheries

New line weighting regimes for commercial longline fisheries can significantly reduce seabird deaths on baited hooks. The challenge now is to encourage uptake.

Thousands of albatrosses and petrels drown on commercial fishing hooks in the southern hemisphere each year.

Some fisheries are well regulated, especially those overseen by the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR), and incorporate a range of seabird bycatch mitigation methods into their operations. These include seasonal closures, night setting of fishing gear, streamer lines that scare birds when the gear is being set, and line weights that rapidly draw baited hooks below the diving depth of seabirds. In the mid-2000s these measures saw seabird bycatch decline by up to 100% in toothfish fisheries throughout most of the Southern Ocean. However, seabirds are still at risk in many poorly regulated or unregulated tuna and billfish fisheries operating in sub-tropical waters.

Australian Antarctic Division seabird ecologist Dr Graham Robertson has worked with the fishing industry for decades to help develop practical and effective technologies and strategies to save seabirds, without compromising fish catch rates (see story on page 16). His work feeds into CCAMLR, various regional fisheries bodies, Australia's domestic fisheries regulations, and the Agreement on the Conservation of Albatrosses and Petrels (ACAP), which coordinates international activity to mitigate known threats to seabird populations.

He said one of the biggest barriers to the uptake of seabird bycatch mitigation measures in tuna fisheries is the reluctance to change traditional fishing practices, coupled with a lack of incentives to adopt seabird friendly practices.

'Fishing industries are generally wary of changes that could affect their catch rates,' Dr Robertson said.

'But it's part of the job of scientists and policymakers to work with fishers and demonstrate that there are better ways of doing things that benefit both their operations and seabirds. This is a slow, cooperative process involving industry leaders, engineering and experimental manipulation, data analysis and reporting. But when things work well, the results are adopted by management organisations and embedded in fisheries management regulations.'

One of Dr Robertson's latest successes is the development of a new line weighting regime for pelagic (open ocean) longline fisheries, in collaboration with a Queensland tuna fisherman, the Australian Fisheries Management Authority and an engineering company in the United Kingdom that specialises in manufacturing bycatch mitigation technologies.

While the new regime is being voluntarily adopted by fishing operators in Queensland, it is a conceptual step-change on current best practice line weighting recommendations and it may take time to convince the international community of its merits.

'The idea involves using a new type of sliding lead weight at the hook; or near the hook in regions where shark bite-offs are common,' Dr Robertson said.

'It sounds quite simple, but the new regime had to offer improved, cost-effective seabird deterrence via rapid sink rates, improved crew safety, and no reduction in fish catch. It also had to facilitate in-port inspection of gear for compliance purposes. Getting all these elements to align was a challenge.'

To understand why the new weighting regime is significant requires a short historical deviation.

According to ACAP, best-practice line weighting offers fishers three weighting options that position different sized lead weights at different distances from the hook. The weighting regimes all involve long 'leaders' (the distance between the lead weight and baited hook), resulting in slow sink rates. The regimes were developed in the days when longlines were unweighted and resistance to the addition of weight was fierce, due to fears the weights would reduce fish catch.



- This photograph of a drowned wandering albatross has helped galvanise international support for research that saves seabirds in longline fisheries. It has been used by countless media and research organisations.
- Bins of longlines using Lumo Leads on a fishing vessel in Queensland. With leads at the hook the lines can be easily viewed by compliance officers and they reduce tangles in the lines during setting.
- 3. A bin containing longlines running swivel leads, some of which have been placed in view for the photograph. Normally there would be about 350 lead weights like this buried within about 5–7 km of monofilament branch lines (lines branching off the main line) in each bin.
- 4. Dr Robertson in 2006 onboard a Spanish rig longliner off southern Argentina. He used funds from a Pew Fellowship in marine conservation to conduct a line weighting experiment of relevance to the CCAMLR toothfish fishery and is holding a custom-made weight.

'A compromise was needed. So we embarked on a stepped approach working with progressive fishers and did some trials testing the effect of lead weights at six metres from the hook, then at four metres and eventually at two metres,' Dr Robertson said.

In 2011, the Queensland fisherman Dr Robertson was working with suggested they try putting the lead at the hook.

'He was taking a big risk; for all we knew his fish catch and income may have been reduced and he had a family to support,' Dr Robertson said.

The pair sketched some designs and approached bycatch mitigation technology company, Fishtek Marine, who added their ideas and eventually manufactured a sliding lead that they called the 'Lumo Lead'.





Unlike conventional swivel leads which are tied or 'crimped' into the line, sliding leads are attached in such a way that if the line breaks under tension, the lead slides off the line, rather than flying back like a cannon ball at the person on the other end.

Fishtek Marine also designed a luminescent nylon sheath for the lead (conferring the name Lumo Lead), with the potential to attract fish. Because the leads sit just above the hook and don't need to be crimped in, the lines are faster and easier to construct and the weights do not get tangled within the coils of line. The leads are also clearly visible when they're sitting in bins on the deck, making it easy for compliance observers to see whether weights are being used. And the luminescent coating prevents deckhands from contacting the lead. 'Our trials showed that lines with lead at the hook sank instantly, giving seabirds little time to attack the baits. And there were significant operational advantages to crews as well, which helped voluntary uptake by fishers,' Dr Robertson said.

Because the at-risk seabird species do not occur in Queensland waters, the trials were unable to determine the impact of the sliding leads on seabird bycatch. However, at about the same time Dr Robertson's trials were underway, another study was being conducted by Uruguayan researchers in the south-western Atlantic, where major seabird bycatch events have been recorded. The Uruguayan trials looked at the impact of reducing the distance between the lead weight and the hook on seabird bycatch and pelagic fish catches. The team provisionally reported a 50% reduction in seabird bycatch on lines using 65 g weights at one metre from the hook, with no other mitigation measures.

'The Uruguayan data helps show that if you have fast sinking lines, you're going to save seabird lives, without any other mitigation,' Dr Robertson said.

'Based on my experience in Queensland, where tuna operators are voluntarily adopting the new line weighting regime, we can be fairly confident that this approach to line weighting has great promise.

'It's time to be pragmatic about unregulated fisheries. Many fishermen resent using streamer lines and 95% of the time there are no independent observers onboard vessels to ensure compliance. With this new line weighting, fishers can't take the leads out when they're at sea, and inspectors can simply walk around the docks and check the gear for compliance.'

It may take some years yet for Dr Robertson's vision to be realised, but the technology, research, political will and environmental climate are beginning to align.

WENDY PYPER

Corporate Communications, Australian Antarctic Division

A life dedicated to saving seabirds

Dr Graham Robertson has worked in the field of seabird ecology and seabird bycatch mitigation at the Australian Antarctic Division for the past 26 years.

Much of his work has involved research at sea to understand the interactions between albatrosses, petrels and fisheries, developing and implementing solutions to the problem of seabird mortality in longline fisheries, and advising national and international management and conservation bodies on bycatch mitigation.

His first job at the Antarctic Division, however, was a world away from where his future lay.

'I came to the Antarctic Division in my mid thirties with a background in agriculture and botany, and my first job involved overwintering at Mawson for 14 months and studying the foraging ecology of emperor penguins,' Dr Robertson said.

'I was really interested in field biology and thought this was the best job in the world working with a beautiful bird that's supremely adapted to its environment.'

A few years later, however, the issue of seabirds dying in longline fisheries captured his imagination and a deep-seated attraction to the conservation imperative. By the mid 1990s Dr Robertson was looking for a way in.

'I decided I needed to get some experience and to understand the culture and practice of longlining, so I went to sea on Japanese high seas tuna boats as an observer and to conduct some experiments on a number of occasions. Not long after that the issue of birds dying in Patagonian toothfish fisheries was raised at the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR), so I got involved in that.' Dr Robertson attended the first meeting of the seabird bycatch working group of CCAMLR in 1996 and began working with toothfish fishers in the Falkland Islands. Over the next 10 years his work with both fisheries and CCAMLR contributed to conservation measures that virtually eliminated seabird bycatch in CCAMLR-regulated toothfish fisheries.

'In 1997 some 5750 albatrosses and petrels were killed in South Georgia alone, but by 2007 the numbers of birds caught had declined to zero. It was a remarkable success story,' he said.

He has since turned his attention back to tuna fisheries, most of which operate outside of CCAMLR, and which continue to catch unsustainable numbers of seabirds (see story on page 14).

On his retirement from the Antarctic Division in July 2014, Dr Robertson said his most satisfying achievements were the implementation of science programs that resulted in changes to the conservation measures of CCAMLR and various tuna commissions, as well as changes to Australia's domestic fisheries regulations.

'It is not easy to get wins but when you do it is pretty satisfying,' he said.

Dr Robertson plans to continue work in the seabird bycatch sphere, including work on his award-winning underwater bait setter for tuna fisheries. This high-tech machine instantly fires baited hooks 10 m deep, from the back of fishing vessels, and has the potential to completely eliminate fishery interactions with seabirds. Some of the money to develop this technology has come from the sale of a number of Dr Robertson's emotive photographs of the beautiful and charismatic birds he aims to save. Signed photographs are provided to Antarctic and subantarctic tourism operators who auction them off to their clients.

'I think the tourists like the idea that the photographs were taken by the person doing the research,' he said.

Reflecting on his time with the Antarctic Division, Dr Robertson said he was grateful to have been supported in his passion to see fisheries operate more sustainably.

'I like working at the interface between conservation biology and primary industry

in this case fisheries – because primary
industry is how the real world operates and this
is where you can make a difference,' he said.

'It's thrilling and satisfying to make a science finding that gets incorporated into management. It means all the years of trials and uncertainties have worked out.'

WENDY PYPER

Corporate Communications, Australian Antarctic Division

 Dr Robertson (left) and Dr Roger Kirkwood on a rock stack called lldefonso, south west of Cape Horn, at the end of a challenging field program working with black-browed albatrosses.

Deep sea cameras reveal limited impact of fishing around Heard Island

Novel deep sea camera systems have shown that Australian commercial fisheries are having little impact on seafloor biodiversity around Heard Island and McDonald Islands (HIMI).

In combination with scientific sampling, the cameras revealed that more than 98% of sensitive seafloor biodiversity in the HIMI fishery remain in pristine condition following commercial fishing over the past 16 years.

The eight-year study, funded by the Fisheries Research and Development Corporation, was a joint project between the Australian Antarctic Division, the Australian Fisheries Management Authority and fishing industry partners, Austral Fisheries and Australian Longline.

Australian Antarctic Division fisheries scientist, Dr Dirk Welsford, said the project aimed to investigate the potential impacts and sustainability of trawling and longlining for Patagonian toothfish in the Australian Fishing Zone at HIMI, and to develop technologies that could be used by other fisheries to address similar issues.

A key part of the project was the development of underwater still and video camera systems, which attached to trawling and longlining ('demersal') fishing gear to observe the impact of the gear on seafloor habitat.

'The cameras were designed for easy use by the fishing industry,' Dr Welsford said.

'They are robust, automated systems that can be deployed on fishing gear to allow fishing vessels to see whether the habitat they are working in contains sensitive seafloor species, and what happens when fishing gear disturbs organisms on the seafloor.'

This video footage, along with scientific sampling of seafloor communities, was used to assess the risk of demersal fishing to those communities and to identify strategies to minimise fishing impacts, such as gear modification or the avoidance of sensitive areas. 'Our study showed that the majority of vulnerable organisms live on the seafloor at depths less than 1200 m,' Dr Welsford said.

'This range overlaps with the depths targeted by the trawl fishery and to a lesser extent by the longline fishery. However, as the majority of trawling has focussed on a few relatively small fishing grounds, less than 1.5% of the biodiversity in waters less than 1200 m are estimated to have been damaged or destroyed.'

The study estimated that 0.7% of the sea floor within the HIMI fishing zone has had some interaction with fishing gear since the fishery's inception in 1997. It also estimated that the HIMI Marine Reserve, where fishing is not permitted, contains over 40% of the seafloor organisms considered vulnerable to demersal fishing at HIMI.

'A key element of the management strategy for mitigating the impact of demersal fishing is the extensive marine reserves established around HIMI and Macquarie Island,' Dr Welsford said.

'This work has directly led to the expansion in March this year of the HIMI Marine Reserve by 6200 km², to protect a range of distinct seafloor habitats and vulnerable species of conservation significance. The HIMI Marine Reserve now covers over 71 000 km².'

The report concluded that the risk that fishing will cause significant impacts to seafloor biodiversity at HIMI is likely to be low over the medium term. It recommended that risk assessments for the fishery be updated regularly, to evaluate the likely performance of the current management approach in the long term.



The results of the study will help inform discussions with the Commission for the Conservation of Antarctic Marine Living Resources, which manages fishing activities in the Southern Ocean, as well as international conversations on demersal fishing impacts. WENDY PYPER

Corporate Communications, Australian Antarctic Division

- Some of the diverse seafloor habitat captured by the trawl-mounted camera during testing in the Southern Ocean.
- 2. One of the deep sea camera systems, designed to attach to trawl gear.



 Dr Alison Kohout with two of her wave sensors on the stern of the Aurora Australis during the Sea lce Physics and Ecosystem eXperiment (SIPEX-II) voyage in September 2012. The logistical component of her research was supported by the Australian Antarctic program.

Stormy seas ahead for sea ice longevity

Stormy seas whipped up at the edge of the Antarctic sea ice zone can send large ice-breaking waves hundreds of kilometres into the pack ice.

The discovery, published in the journal *Nature* in May, suggests that large ocean waves play a bigger role in sea ice breakup and retreat than previously thought.

Hydrodynamics scientist and lead author of the paper, Dr Alison Kohout, of the National Institute of Water and Atmospheric Research in New Zealand, said increasing storminess in the Southern Ocean could accelerate sea ice retreat in the future, with implications for sea ice processes and marine creatures.

'Waves propagating through the Marginal Ice Zone (MIZ) leave behind a wake of broken ice floes, which are then more easily broken up and deformed by winds and currents,' she said.

'This mixing and churning eliminates the sea ice barrier between the air and the ocean and increases heat exchange between the atmosphere and the ocean.' The MIZ is a region of broken ice floes, hundreds of kilometres wide, that forms at the boundary of the open ocean and the pack ice. Predicting the scale of ice breakup requires an understanding of how far waves move into it.

To find out, Dr Kohout braved sea sickness during the Australian-led Sea Ice Physics and Ecosystem eXperiment-II (SIPEX-II) in September 2012, to deploy five wave sensors on sea ice floes — from the edge of the MIZ to some 200 km inside it.

Along this deployment transect the average floe diameter increased from 2–3 m at the ice edge to 10–20 m, while the ice thickness was estimated at between 0.5 and 1 m thick.

The wave sensors transmitted information about their vertical acceleration to a satellite for up to 40 days. During this time they measured wave heights up to seven metres at the ice edge and three metres some 240 km inside the ice edge.



deeper into the MIZ. However during large 'wave events' — over three metres high — the wave height did not decay exponentially, allowing the wave to persist deep into the pack ice. To test her theory that an increase in large

Dr Kohout found that in calm conditions, wave

heights dropped exponentially* as they moved

wave events would cause the sea ice edge to retreat, Dr Kohout compared model estimates of wave heights with satellite sea ice observations between 1997 and 2009.

'We found that the retreat and expansion of the sea ice edge correlated with significant wave height increases and decreases respectively,' she said.

'A two metre increase in significant wave height over a decade led to a two degree latitudinal retreat in ice extent.'

Dr Kohout found that the largest increases in wave height occurred in the Amundsen-Bellingshausen Sea, where regional sea ice retreat is well documented. Similarly, the largest wave height decreases were in the Western Ross Sea, where sea ice has expanded.

'Our results suggest that sea ice is vulnerable to changes in storminess. The southward shift in storm tracks over recent decades has resulted in fewer cyclones at mid latitudes and more cyclones at higher latitudes,' Dr Kohout said.

'In the future, wave heights are predicted to increase everywhere at the sea-ice edge in the Arctic and Antarctica. So it is conceivable that this will accelerate sea-ice retreat.'

WENDY PYPER

Corporate Communications, Australian Antarctic Division

*Exponential growth can be pictured as a cell dividing into two and then those two cells also dividing into two and so on, so that the number of cells doubles each time. Exponential decay is the same, but in the negative direction. (Any number, other than two, can be used as the base number). A similar concept applies to the reduction in wave energy as it passes through sea ice.

Journey of discovery for Antarctic heritage specialists

What do baling hooks, tins of Vegemite, a pair of Russian boots, a Weasel, and an airplane wheel have in common? They are all part of a diverse artefacts collection at the Australian Antarctic Division.

With artefacts originating from the Heard Island sealing days, Douglas Mawson's Cape Denison expedition, and the Australian National Antarctic Research Expeditions (ANARE), the Australian Antarctic Division has an extensive and eclectic heritage collection.

The artefacts range from delicate textiles to large machinery and provide an excellent illustration of Australia's Antarctic journey through time. However, the Antarctic Division is not a collecting institution and does not have the in-house expertise or resources to properly conserve and manage artefacts.

To address this problem, the Division established a Heritage Collection project in May 2014, in partnership with the National Museum of Australia (NMA). The project is systematically assessing the significance and condition of the artefacts and developing recommendations to ensure the collection is properly managed into the future.

The project has three stages:

- audit the collection;
- develop methodology to assess the significance of the artefacts; and
- apply the methodology and develop recommendations for future care arrangements.

The first stage is nearing completion, with the systematic audit of over 700 artefacts held at the Kingston Headquarters. The audit was undertaken by a consultancy team headed by Anne McConnell, a Tasmanianbased heritage specialist who has previously worked in Antarctica. Anne's auditing team also included Linda Clark, who has extensive heritage and Antarctic experience, and Debbie Robertson, who has previous experience with the Antarctic Division's artefacts collection and database. The audit involved researching and photographing each artefact and entering this information into the Division's heritage database.

It hasn't been an easy task for the team. As many of the objects had no information about their history or use, the assistance of some long term Antarctic Division employees or ex-employees was sought. Without their invaluable assistance, so much background information or provenance would have been lost. There are still a small number of items requiring more information, which we are pursuing.

At the same time, the NMA organised for a significance report, undertaken by Bernadette Hince, on a sample of the Antarctic Division's heritage collection. The initial report has researched the significance of a selection of objects, breaking the collection down into four major historical eras.

- The sealing era: sealing activities on Heard Island (commencing around 1855) and Macquarie Island (commencing 1810).
- 'Heroic' era: late 19th to early 20th Century, including Sir Douglas Mawson's Australasian Antarctic Expedition of 1911–14.
- 'Pre-ANARE' period: 1915–1946, which includes the British Australian New Zealand Expeditions of 1929–30 and 1930–31.
- The modern era: ANARE (1947–2002) and today's Australian Antarctic program.

The methodology used in the report will be applied to the remainder of the collection by the NMA in conjunction with the Antarctic Division, to help develop recommendations on the future location, curation, conservation and display of the collection.

The project so far has literally been a journey of discovery. Many boxes and containers had not been inspected for years and each one has held many interesting artefacts that help tell Australia's Antarctic story. While some discoveries have been exciting, like the collection of dog-haul and man-haul sledges, others have been very disappointing, such as finding water damage to a 1960s ration box. All up, over 400 artefacts are new entries into the heritage database.

Part of the project has involved, and will continue to involve, consulting with a variety of museums and other important stakeholders, such as the ANARE Club. For further information contact deborah.bourke@aad.gov.au.

DEBORAH BOURKE

Senior Policy Adviser, Australian Antarctic Division







- A barge caravan (yellow and white vehicle) arrives for auditing after 10 years' storage at the Queen Victoria Museum and Art Gallery in Launceston, Tasmania.
- 2. Linda Clark cleans artefacts in the warehouse.
- 3. Antarctic Division library assistant, Graham Watt, inspects a man haul sledge.

HISTORY



- 1. Roger Handsworth installs the Zeiss camera in a helicopter in Victoria in 1993.
- 2. Part of a vertical aerial photograph of Adélie penguin colonies on Kazak Island, Vestfold Hills, taken with the Linhof camera on 24 November 1993.
- 3. A vertical aerial photograph of the Long Fjord area of the Vestfold Hills, Antarctica, photographed at 4500 metres above sea level with the Zeiss camera, 11 February 1997.
- 4. An oblique aerial photograph of Mawson Escarpment, Antarctica, taken for geological research on 24 January 1998 with the Zeiss camera. Roger Handsworth built a special stand and yoke to hold the camera out the window of the Sikorsky helicopter as it flew a flight path parallel to the escarpment face, at a distance of about one kilometre.

Australia's Antarctic aerial history archived

Camera equipment used for nearly two decades to capture aerial images of Australia's Antarctic territory and its subantarctic islands has been donated to the Tasmanian Museum and Art Gallery.

The two film cameras and a GPS unit were used by the Australian Antarctic Division to take aerial photographs for large scale mapping and for penguin and seal counts. The maps generated from these photographs are still used today for station and field operations, including field trips, aviation and management of the station environs.

The first camera, a Zeiss UMK1318 'metric' or mapping camera, was deployed in helicopters from 1993 to 2003, primarily to photograph the Windmill Islands, Vestfold Hills, Larsemann Hills, Holme Bay, Framnes Mountains, northern Macquarie Island, and the buildings and services at Australia's Antarctic stations. The camera operated alongside an Ashtech Z-12 GPS unit, used to record the coordinates of each photograph.

Engineer, Roger Handsworth, installed the camera in the Squirrel and Sikorsky helicopters used by the Division, and modified or built equipment to enhance the camera's use.

'We stored flight plans in a flight navigation program on a laptop computer and these plans would appear on screen as lines, with the coordinates for each photo that we wanted to take displayed as little circles,' Roger said.

'We had the GPS feeding into the computer as well, so that when the pilot flew through a circle in the flight plan, the computer would trigger the camera controller, which would then fire the camera and advance the film.'

Roger acted as the aerial photography coordinator on many flights over the decade, alongside a pilot and a surveyor, clocking up some 411 flight lines, with each line recording many photographs. Most photos were taken at 10 000 ft (3000 m) with an occasional venture to 15 000 ft (4500 m), with oxygen. The aerial photos were taken with a degree of forward and side overlap so that they could be matched for mapping purposes later.

While most photos were taken from a position underneath the helicopter, on one occasion Roger built a camera stand that allowed the camera to be positioned at a horizontal angle out the helicopter window, to photograph the Mawson Escarpment – a precipitous ridge of rock towering up to 1000 m above the Amery Ice Shelf.

The second camera, a Linhof Aerotronica 69, was deployed in helicopters from 1986 to 2000 to take low altitude aerial photographs of seal and penguin colonies, and lakes. It was used at the Windmill Islands, Vestfold Hills, Heard Island, Larsemann Hills, Mawson Coast and Rauer Group of islands, across some 600 flight lines.



From an altitude of 500 m and 750 m, the camera's 175 mm telephoto lens provided high resolution images that were used by biologists to count emperor and Adélie penguins and elephant seals.

In the early 2000s, film cameras began to be replaced with digital cameras and satellite images.

Former Australian Antarctic Division Mapping Officer, Henk Brolsma, who organised the donation of the cameras to the museum, said changes in technology have reduced costs in some cases, but also required new approaches.

'Since our last aerial photography flight, high resolution satellite imagery with a resolution of 0.5 m has made it more efficient and costeffective to derive geographic information suitable for producing 1:25 000 maps,' he said.

'However, satellite imagery is still not suitable for mapping stations or counting animal populations, and a new digital aerial camera capable of capturing imagery at the resolution of the Zeiss camera costs about \$1 million and requires a fixed-wing aircraft set up for that purpose.

'The way of the future is to use drones with suitable cameras and airborne scanners, technicians with a "flying" licence and the ability to process the imagery and scanner data.'

Mr Brolsma is pleased that an important part of Australia's Antarctic history will be remembered through the Tasmanian museum's collection.

'The museum has a number of aerial cameras used in Antarctica in its collection, so it is fitting that these cameras become an integral part of that,' he said.

'They are probably the last film cameras to be used for aerial photography in the Australian Antarctic Territory, so it closes a chapter in the technology's history.'

WENDY PYPER

Corporate Communications, Australian Antarctic Division





Aurora Australis celebrates her 25th birthday

Hobart's Antarctic community celebrated the 25th anniversary of the launch of Australia's icebreaker *Aurora Australis* in September, with an intimate lunch on the ship's helideck, as she sailed up the Derwent River.

The iconic orange ship, owned by P&O Maritime, was launched at Newcastle's Carrington Slipways on 18 September 1989 by Mrs Hazel Hawke — wife of former Australian Prime Minister Bob Hawke. The ship entered Antarctic service in the 1989–90 season, with Australian Antarctic Division fisheries scientist, Dick Williams, the first Voyage Leader on her maiden voyage to Heard Island.

Since then the ship has enabled scientists to conduct critical research in Antarctica, the subantarctic region and the Southern Ocean. This includes two large marine surveys off East Antarctica in 1996 and 2006, focusing on the distribution and abundance of Antarctic krill, as well as ocean physics and chemistry. The resulting scientific papers fill numerous journal volumes.

The ship also played a key role in the International Polar Year, with Australian and international scientists conducting a census of Antarctic marine life that contributed to the recently published *Biogeographic Atlas of the Southern Ocean* (see In Brief).

In 2007 and 2012 the ship again carried international contingents of scientists into the sea ice zone to conduct highly detailed studies on the structure, thickness and snow properties of sea ice and their effects on sea ice algae and the marine ecosystem. Among other things, this research is helping to validate satellite measurements of sea ice thickness and extent that contribute to climate models.

The Aurora Australis has also facilitated the adventure of a lifetime for first-time expeditioners, as well as delivering critical cargo to Australia's Antarctic and subantarctic stations. The ship can carry up to 700 tonnes of cargo and 1.1 million litres of fuel, essential for various building programs at the stations and Wilkins Runway, as well as ongoing station maintenance and operation.

Of course it hasn't all been smooth sailing. In 1998 and 1999 engine room fires broke out while the ship was in transit to Antarctica. The ship has also been beset a number of times as thick sea ice thwarted her 1.23 m icebreaking capability. Most recently *Aurora Australis* was involved in the rescue of passengers from another beset ship, the *Akademik Shokalskiy* from Commonwealth Bay in 2014.



- 1. Members of the Hobart Antarctic community enjoy lunch on the helideck of the *Aurora Australis* to celebrate her 25th birthday.
- 2. The Aurora Australis is a much-loved symbol of the Australian Antarctic program.



New icebreaker update

In July the Australian Government took the next step towards construction of a new Antarctic icebreaker to replace the 25 year old *Aurora Australis*, releasing a detailed Request for Tender to two prequalified companies.

The Request for Tender is seeking a ship that will have:

- the ability to break 1.65 m thick ice while maintaining a speed of three knots;
- a cargo capacity of 1200 tonnes;
- accommodation for 116 expeditioners;
- capacity to operate four light or two medium helicopters;
- the endurance to support voyages of up to 90 days;
- a medical facility that supports surgical, radiographic and telemedicine capabilities.

The new icebreaker should be operating by the 2019-20 Antarctic season and will be based in Hobart. A fact sheet on the capabilities required of the new ship is available at www.environment.gov.au/minister/hunt/2014/pubs/mr20140731-factsheet.pdf.

While a new ship with greater icebreaking, scientific and cargo capabilities is an exciting development for Australia's Antarctic program, the eventual replacement of *Aurora Australis* will be tinged with nostalgia for the thousands of expeditioners who have become part of her history.

WENDY PYPER Corporate Communications, Australian Antarctic Division

Paddle unites Australian and Antarctic deserts

A painted wooden paddle presented to the Australian Antarctic Division by Aboriginal artists last year, will be displayed onboard Australia's Antarctic icebreaking ship *Aurora Australis* this Antarctic season.



WENDY PYPER

The Wiluna paddle was presented to the Australian Antarctic Division because its representation of the dry, hot Australian desert shares a connection with the frozen Antarctic desert. Both the Australian and Antarctic desert environments are perceived as desolate, unforgiving and harsh, and yet both environments support enormous ecological diversity. Both deserts are also remote and fragile.

The Wiluna paddle was painted at the World Indigenous Network Conference (see side bar) in Darwin in 2013 by Ms Lena Long, with advice from Ms Roxanne Anderson. Both artists are members of the Martu language group from the township of Wiluna, within the Western Desert of Western Australia. The paddle contains images of Ms Long's country. On one side there is a ghost gum tree, which reminds her of her childhood and which has cultural significance to Martu people. The other side depicts the wells of the Canning Stock Route, where Ms Long was born and grew up.

On 29 July this year the paddle was presented to the Master of *Aurora Australis*, Captain Murray Doyle, by Australian Antarctic Division Strategies Branch General Manager Mr Jason Mundy. The paddle will be displayed in a prominent position onboard the ship, to remind travellers to Antarctica of the links between the Australian and Antarctic deserts.

'It is appropriate that a paddle from a vast and distant region of Australia, designed to unite people to a common purpose, should have a long voyage to another vast and distant place, where Australians are working together to conduct globally significant work,' Mr Mundy said.

WENDY PYPER

Corporate Communications, Australian Antarctic Division

Paddles inspired by Magic Canoe

The inaugural World Indigenous Network Conference, held in Darwin in May 2013, attracted 1300 delegates from First Nations across 55 countries to share indigenous knowledge about land and sea management in the face of climate change.

As part of the conference our social engagement group, Paramodic, initiated an artistic collaboration amongst the delegates, based on the 'Magic Canoe' – the inspiring story of how indigenous Canadians united to save their rainforest home from logging. The story has since become a metaphor for large-scale transformation and social change. In five days our team collected more than 100 stories as videos, one-on-one interactions and painted art, including 55 painted paddles.

Many of the stories we collected contain practical, innovative and insightful knowledge about dealing with changing climate. Indigenous Peoples are links to unbroken chains of human knowledge stretching back tens of thousands of years, and they are deeply concerned they will be the last ones to hold this knowledge.

The paddles are message sticks, connecting people to share this knowledge, and have been sent to 26 countries on every continent. They have become an enduring symbol of the World Indigenous Network and the connections made in Darwin. You can follow the stories of the paddles at www.paramodic.com/paddles. DR RUTH MIRAMS

Paramodic Pty Ltd

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- Mr Jason Mundy, General Manager of the Australian Antarctic Division's Strategies Branch (left) presents the Wiluna paddle to the Master of Aurora Australis, Captain Murray Doyle (right).
- 2. Ghost gums depicted on the Wiluna Paddle.
- 3. Wells of the Canning Stock Route depicted on the Wiluna Paddle.

Landscape rehabilitation in the Vestfold Hills

A 'leave no trace' philosophy can be successfully applied to geotechnical investigations in the Antarctic landscape.

The Vestfold Hills undulate on the edge of the Antarctic continent covering over 400 square kilometres. They consist of low-lying pale metamorphic bedrock, criss-crossed with a network of black dolerite dykes you would swear were someone's attempt to play noughts and crosses on a continental scale. Spread over this patterned rock in patches of various thickness lie drapes of mud, sand, gravel and boulders (some as big as caravans) that have been dumped by the retreat of the Antarctic ice sheet that covered the area during numerous ice ages. At first glance, this landscape of loose, jagged, poorly sorted glacial till (or moraine) could be mistaken for Mars, with no trees or bushes; nothing but salt encrusted soil and barren rocks.

Nestled on the edge of these hills overlooking the island-dotted Prydz Bay is Davis station, established in 1957 by Phillip Law (then Director of the Australian Antarctic Division). Ever since Davis and Australia's two other Antarctic stations (Casey and Mawson) were established, investigations into the most practical and cost effective way to access them have ensued. These include investigations into the possibility of landing small fixed-wing aircraft in Davis's back yard. Aircraft remain vital to supporting activities in Antarctica and there is a continuing need to look for ways to improve the safety and reliability of aviation operations. Since the 1960s, several investigations have been carried out literally to test the ground around Davis. During the early 1980s, in particular, there was a concentrated effort to perform site investigations, which involved excavations by heavy machinery that pushed up soil mounds, dug pits and pushed boulders aside to make access paths through the area. Back then, it seems disturbing the landscape was not considered a serious issue and no efforts were made to tidy up afterwards. Today you can still see pits, mounds, excavator tracks and cleared paths that have persisted for over 30 years. There is no rain to wash the evidence away or wear down the mounds and ruts. Instead, the landscape is scoured by wind, with occasional flooded patches from melting snow banks. Preservation of these earthwork features appears to depend on the cohesion of the sediments affected. Sandy, non-cohesive sediment shows redeveloped desert pavement in most settings, with excavations and tracks defined by the unnatural distribution of boulders. Clayey, cohesive sediment preserves wheel ruts and some imprints of excavator tracks.

In 2012–13 another small scale geotechnical investigation was carried out in some of the same areas as before, but this time disturbance to the ground was managed sensitively. Every effort was made to remediate all sites, to remove any evidence of activity. Excavation was mostly restricted to hand digging and auguring to avoid the use of heavy machinery, however an excavator and machine auger were used on existing roads where there was pre-existing disturbance. For all excavations a simple yet effective method was devised, with the material removed being carefully placed on boards next to the holes, keeping the stratigraphy (layering) in correct reverse order. This meant that when the samples had been taken and ground features logged, the material could be replaced in the hole in correct order, thereby retaining original material colour and grading. Some careful raking and smoothing of the surface, and replacement of larger rocks to their original position, resulted in no detectable disturbance.



To assess the recovery of these minor excavations each site was inspected 12 months after disturbance. Pleasingly, there was only minor evidence at some sites, only noticeable to a trained eye looking for evidence. It is doubtful these minor disturbances would be detected by anyone wandering past without prior knowledge of the activity; in fact, the observer would probably leave more impact with their own footprints.

These investigations reveal some interesting changes in attitude to environmental management. The Antarctic Treaty (Environment Protection) Act of 1980 was in effect for both investigations, but at some point between then and now our attitude to this pristine glaciated environment has matured into a respectful responsibility. Every activity approved in the Australian Antarctic Program must seek and gain environmental authorisations and/or permits through the Antarctic Treaty System before environmental disturbance can be performed. As part of this process each activity is scrutinised for recovery procedures and mitigation processes to ensure the human 'footprint' in Antarctica is kept to a minimum.



The question remains whether remediation of the old workings is feasible, when it is no easy task to access these areas and doing so may well create more disturbance than is there already. However, with good planning and adherence to technique and process, as evidenced by the activities outlined above, it is possible to ensure that impacts are minimised or negated altogether. DR BARBARA FRANKEL Antarctic Modernisation Program

- Field Assistant Matt Donoghue inspects a hand-augered site 12 months after excavations. No evidence of disturbance is observed and the soil is now encrusted with salt.
- 2. Davis station with dolerite dykes criss-crossing through the station and across the Vestfold Hills in the background.
- The soil excavated from this hand-augured borehole was kept on nearby boards so that it could be replaced in the correct stratigraphic order.
- 4. Evidence of large tracks from workings in the 1980s.

The Antarctic Selection

Sterile zones, scalpels and sutures were the last thing boiler-maker Cliff Simpson-Davis expected to be boning up on before he took on his new role as a 'tradie' at Davis station this year.

But the Royal Hobart Hospital operating theatre is exactly where he found himself, undertaking lay surgical training during his pre-departure preparation with the Australian Antarctic Division in Hobart.

'It was amazing to be able to participate in this totally alien medical world – even for just a short amount of time,' Mr Simpson-Davis said.

'We observed and learnt about a range of operating theatre procedures, including anaesthetics, patient care and handling sterile instruments.'

Even before the team started scrubbing up at the hospital, they had already made it through a rigorous recruitment process. Each year thousands of hopefuls apply to be part of the Australian Antarctic program, but only about 10% of these ever set foot on the ice.

The first step in the journey to become a wintering expeditioner is an online application, followed by a technical shortlisting. The Antarctic Division's Human Resources Manager, Andrew Groom, said applicants need to meet a range of technical shortlisting requirements.

'All expeditioners have to be generalists and possess a wide range of skills in their specialist area,' Mr Groom said. 'For example, there's often only one electrician or plumber on station over winter. This means they need to be able to fix, build and troubleshoot any issue that might arise.'

Once the Antarctic hopefuls are through the technical short listing, their personal qualities are assessed through a 'selection centre'.

'We bring a group of applicants together for a 24 hour assessment,' Mr Groom said.

'We run them through a series of scenarios and activities to assess personal qualities. We're primarily looking at their awareness of their effect on others and how they manage that.'

The next stage of the application process is an adaptability assessment that focuses on how people deal with isolation and separation from loved ones, and living and working in a small isolated community. The final stage of the process is a rigorous medical examination.

'The diversity of people on station makes it a fascinating place to work and we are looking for people who have the ability to adapt to those conditions and work as a united team in what can be challenging circumstances,' Mr Groom said.

Once expeditioners have been chosen, they spend several months at the Division's headquarters in Kingston undertaking intense pre-departure training. Here they learn all the skills they need to spend a year in the most isolated place on Earth, from search and rescue training, to boating and Hägglund driving. The wintering crew also spend four days learning fire-fighting skills with TasFire Training.

TasFire Training Instructor Nigel Reid visited Australia's Mawson, Davis and Casey stations to get a better understanding of the exceptional conditions surrounding fire-fighting on the ice.

'Antarctica throws up some unique challenges. Not only do you have to contend with the usual heat, flames and smoke encountered in any blaze, but you also have the added issue of maintaining water supply, with hoses freezing in the extreme outside temperatures,' Mr Reid said.

'Additionally, the station buildings are designed for their thermal properties, with triple glazed glass and super-insulated walls, so breaking through this to escape or gain access to the fire is impossible.'

Each station has specially designed fire-fighting equipment loaded on a fire Hägglund, which is deployed in the event of a blaze.







'We teach the expeditioners the essentials of fire-fighting; how to keep themselves safe, communications in a fire, the best way to enter a burning building, how to conduct a search for a missing person, and of course douse the flames,' Mr Reid said.

'It is an intense few days, but with ongoing training over winter, the expeditioners become quite competent and confident in how to deal with fire in Antarctica.' Back at the hospital, Davis station wintering doctor, Jan Wallace, is coaching her new lay surgical team on the intricacies of the operating theatre.

'Australia is one of the few Antarctic nations that train a small team of wintering expeditioners, with no medical experience, to act as lay surgical support staff,' Dr Wallace said. 'It can be quite confronting for doctors in Antarctica, as we are the sole medical practitioner expeditioners rely on over the long winter months. So it's good to know that if there was a major emergency, there are others on station who can assist and give the doctor some support or respite if needed.'

As with tradies, all Antarctic doctors have to be generalists; able to perform routine general practice care, emergency surgery and even deal with dental problems. But the enormity of the task has not deterred Dr Wallace, who is heading south for her second Antarctic winter.

'I don't understand people who don't want to go there. It's one of the last big wild places on the planet; the vastness of the landscape is so alluring,' she said.

'The challenge of going down there and living and working is something I savour and I like to think that I've been lucky enough to be able to use my skill set as a doctor, to support something that is part of a bigger and grander picture.'

NISHA HARRIS

Corporate Communications, Australian Antarctic Division





- 1. A fire Hägglund in Antarctica.
- Expeditioners practice using breathing equipment as they enter a burning building.
- A lay surgical team practice assisting Davis station doctor Jan Wallace (left) during training at the Royal Hobart Hospital.
- 4. Antarctic expeditioners learn resuscitation techniques from TasFire Training instructors.



Unlike many of my colleagues here at Mawson, living and working in Antarctica was not a boyhood dream for me. In fact, I only started thinking about becoming a station leader in mid-2012.

It happened while I was a Sergeant with Victoria Police. I was managing a firearms training venue in Port Melbourne when a former station leader, Bill De Bruyen, visited. At the time Bill was a Superintendent with Victoria Police and he had previously worked at Davis station. We got chatting and I got interested and he encouraged me to apply.

To pursue the role I had to resign from Victoria Police, where I'd been a police officer for 20 years. In that time I had worked in busy metropolitan police stations, including Footscray and Sunshine in Melbourne's West, and I had also worked in country police stations, including Wangaratta and Mt Beauty. For a time I was Officer in Charge of a one member police station at Woods Point in Victoria's High Country.

I also worked in pro-active policing roles, including as a Youth Resource Officer and the Victoria Police Gay and Lesbian Liaison Officer. Here I was responsible for establishing and maintaining networks within the Gay, Lesbian, Bi-sexual, Transgender and Inter-sex communities of Melbourne, providing a safe reporting framework while reducing crime in those communities. More recently I moved to a training role where I specialised in firearms, defensive tactics and critical incident management. When I first arrived at the Australian Antarctic Division headquarters at Kingston I was surrounded by experienced station leaders. We went through the initial station leader training together, but then they left me! The station leader training program is approximately 12 weeks long and as they were so experienced they did not need to sit through it all again. So I was on my own. The training consisted of briefings and more briefings. These included briefings from the Polar Medicine Unit, the aviation, environment, policy and media groups, engineering, catering and workplace health and safety, among others. And then there were the science briefings. Each and every person I spoke to was passionate about their program and where it fitted into the big picture, and it was amazing to experience the whole of workforce commitment to the overall objective of science. It wasn't too long into my training when the 'Mawsonites' my team for the next 14 months – arrived and I got busy establishing a relationship with them.

I expected Antarctica to be cold, and when it was announced that I would be coming to Mawson I was told it would be windy too. I was also told Mawson was the most beautiful of all of the three Antarctic stations, due mostly to our ability to travel across the sea ice during winter and onto the plateau and to climb mountains all year round. Back home I spend a lot of time in the outdoors, so on paper Mawson was perfect. And it is. As Station Leader you don't get out as much as you would like to, or as much as the other expeditioners, but when you do it is simply stunning. It is wild and extreme and at times intense, but at the same time calm

Leading Mawson station

What's it like to be a station leader in Antarctica? Former police officer, Steve Robertson, provides an insight into his first time in the role at Australia's most remote Antarctic station.

and peaceful. Before arriving I told myself it will be what it will be, and I worked hard on not conjuring up images in my mind. Now that I am here it is more than what I could ever have hoped for.

Every day presents a new challenge. There are the consistent challenges of working in the harshest environment on Earth — we have had temperatures of -30°C and below and winds in excess of 180 km/h. These conditions are too harsh for us to work outside. However, the weather is more consistently between -15°C and -25°C, depending on the time of the year, and the wind consistently blows at around 50 km/h. These sorts of conditions make the simplest of work tasks challenging.

People also provide a great challenge – particularly ensuring they keep a perspective on things. There are 16 of us on station and over the past seven months we have grown into a family. Just like any family we have our disagreements and squabbles but we also have our share of belly laughs too. Living and working in such an insulated world, it is very easy to lose perspective and the little things, if unchecked, can become big things.

A clear highlight for me during my time here so far was my first trip out to Auster Rookery to see the emperor penguins. It was 30th August, my birthday, and there was not a cloud in the sky nor a breath of wind. The baby chicks had hatched and some were beginning to venture away from their doting and protective parents, which provided for amazing photographs. After my initial photographic frenzy I just lay on the ice and watched them for several hours.





You may not believe me when I say this but I get a real kick out of seeing the Mawsonites get off station. I truly enjoy the thought of them getting out and about and experiencing this amazing place. To see them return with smiles and heroic tales of adventure and to know that I played my part in making that happen is a good feeling.

The skills I have learnt and honed whilst in Antarctica are transferrable to many fields and any managerial role back in Australia. In any given week and on most days I am dealing with human resource issues, logistics, statutory compliance, policy and even media. As summer approaches I will be managing more and more science as well as the construction of two skiways and the coming and going of aviation assets, including fixed wing aircraft and helicopters. Not to mention managing the station's emergency response capabilities in the event of an incident. Whilst none of these skill sets are unique in their own right it is rare to find a single job or role that encompasses them all under the one hat. In fact I am told by ex-station leaders that when I return to Australia I will find it difficult to find any job as challenging or fulfilling as this.

This is not a job for the faint of heart. I believe this role and this experience has significantly increased my self-belief and personal strength. It is stressful and at times very lonely and you need the resolve and strength to stay the course and work through those tough times. You also need a huge dose of humility. You don't know the answers to everything and that is OK. Be comfortable with yourself and don't be afraid to make mistakes, because you will make mistakes. And finally, you need to be able to laugh at yourself because if you can't have a laugh at yourself it is a sad old world.

STEVE ROBERTSON Mawson Station Leader 2014–15

- 1. Steve takes the plunge for the mid-winter swim.
- 2. Mawson Station Leader Steve Robertson tries his hand at being the station chef for the day.
- 3. Steve on his way to Mawson onboard the *Aurora Australis*.
- Being a station leader in Antarctica requires many skills to deal with a broad range of issues, including the ability to occasionally put your feet up.

20 year strategic plan report

An independent report on a 20 Year Australian Antarctic Strategic Plan was released in October. The report, commissioned by the Australian Government, provides a blueprint for Australia's future engagement in the region and options to expand Tasmania's role as a leading Antarctic science and logistics hub.

The preparation of the report by Dr Tony Press, former Director of the Australian Antarctic Division, involved a comprehensive review of Australia's Antarctic interests and consultation with experts, stakeholders and the general public. The process attracted some 27 public submissions including from industry and science bodies, academic institutions, government agencies and the Hobart City Council.

The report provides a broad assessment of the current status of the Australian Antarctic Program and the challenges to maintaining and expanding Australia's status in Antarctic science, operations and diplomacy.

It contains recommendations on a range of issues, including:

- Australia's national interests in Antarctica;
- Supporting and leading national and international Antarctic science;
- Building economic benefits for Tasmania as an Antarctic Gateway city;
- Australia's future Antarctic station operations, transport and deep field traverse capabilities and support for large field-based research campaigns; and
- Effective administration of the Australian Antarctic Territory.

The report is currently under consideration by Government. It is available to download from: http://20yearplan.antarctica.gov.au/final-report

Standing Committees on Antarctica and the Southern Ocean

On 29 October the Senate Foreign Affairs, Defence and Trade References Committee released a report on Australia's future activities and responsibilities in Southern Ocean and Antarctic waters.

The Committee made 19 recommendations, including:

- Researching the impact of changes in the Southern Ocean on the Australian and global climate remains a strategic priority in Australia's future planning and resourcing of scientific research.
- Australia continues its advocacy for the establishment of new Marine Protected Areas in the waters of East Antarctica through the Commission for the Conservation of Antarctic Marine Living Resources.
- The government reaffirms the primacy of the Antarctic Treaty System to Australia's sovereignty and national interests, and continues to support and resource Australia's robust engagement in Antarctic Treaty processes and fora in the pursuit and promotion of those interests.
- Australia commits to re-commencing maritime patrolling in the Southern Ocean.

The full report can be found on the Parliament of Australia website www.aph.gov.au.



(L-R) Australian Prime Minister Tony Abbott, Chinese President Xi Jinping, Administrator of the State Oceanic Administration of China and signatory to the MoU Liu Cigui, and Australian Antarctic Division Director Tony Fleming, at an event for the signing of the MoU.

Australia-China collaboration strengthens

Australia and China reaffirmed and strengthened a long tradition of collaboration in Antarctic diplomacy, science, logistics and operations during a visit from Chinese President Xi Jinping to Tasmania in November.

A bilateral Memorandum of Understanding (MoU) recognising and deepening Australia's and China's Antarctic relationship was signed in the presence of Prime Minister Tony Abbott and President Xi in Hobart. The signing of the MoU was also witnessed by Australian and Chinese expeditioners in Antarctica, via video link to Davis and Zhongshan stations. The key elements of the MoU are:

- A continued commitment to the Antarctic Treaty system, which enables the designation of Antarctica as a natural reserve, devoted to peace and science.
- Establishment of a Joint Committee which will meet every two years, to oversee our cooperation.
- Establishment of a mechanism for environmental, policy, scientific and operational collaboration, including collaborative Australia-China Antarctic science projects.
- Establishment of a platform for Antarctic official and academic exchanges.
- Commitment to utilise Australia, including Tasmania, as an Antarctic 'gateway'.

Atlas of Antarctic marine life

All creatures great and small, from the mighty whale to the miniature microbe, are included in the first comprehensive atlas of Southern Ocean marine life, published in August by the Scientific Committee on Antarctic Research.



The *Biogeographic Atlas of the Southern Ocean* is the culmination of four years' work by an international team of marine biologists and oceanographers from 22 countries, including scientists from Australia.

The 66 chapter atlas includes more than 9000 Southern Ocean species, 800 maps and 100 colour photos. It examines the evolution, physical environment, genetics and possible impact of climate change on Southern Ocean organisms.

The information contained in the atlas is based on data collected during the Australian-led Census of Antarctic Marine Life (CAML) – a marine survey conducted during the International Polar Year in 2007 – as well as data gathered from past decades of research.

CAML leader and former Chief Scientist of the Australian Antarctic Division, Professor Michael Stoddart, said the atlas would provide a baseline for assessing future change to Antarctic marine ecosystems, including the distribution of key species as they adapt to climate change.

'Biogeographic information is fundamentally important for discovering marine biodiversity hotspots, detecting and understanding environmental changes, monitoring biodiversity, and supporting conservation and sustainable management strategies,' Professor Stoddart said.

For more information see the atlas website: http://atlas.biodiversity.aq/index.html.

Horizon science

The international Antarctic community has developed the first collective vision for science in Antarctica during a 'Horizon Scan' in April, convened by the Scientific Committee on Antarctic Research (SCAR).

The vision comprises six scientific priorities that were agreed upon by 75 scientists and policy-makers from 22 countries.

The SCAR Antarctic and Southern Ocean Science Horizon Scan narrowed a list of hundreds of scientific questions to the 80 most critical ones. An overview of these was presented in the journal Nature in August.

The questions fall broadly into six themes:

- Define the global reach of the Antarctic atmosphere and Southern Ocean.
- Understand how, where and why ice sheets lose mass.
- Reveal Antarctica's history.
- Learn how Antarctic life evolved and survived.
- Observe space and the Universe.
- Recognize and mitigate human influences.

The expert group said that answering these questions would require long-term sustained and stable research funding and access to all of Antarctica throughout the year. It would also require the application of emerging technologies, strengthened protection of the region, a growth in international cooperation, and improved communication among interested parties.

'Antarctic science is today particularly important to our understanding of how the Antarctic and Earth system work, what this foretells about the future of our planet and the role that humans play in observed change,' said SCAR President Jerónimo López-Martínez.

'The challenge is to find new ways for the global Antarctic community to act together to realize this potential for the benefit of all.'

SCAR is expected to repeat the Horizon Scan exercise every four to six years in support of national strategic planning efforts and emerging integrated science, conservation and policy efforts.

Sourced from www.scar.org/2014/584-six-priorities-for-antarctic-science and Nature Vol 512: 23–25, 2014.

New HIMI Management Plan

A new Management Plan for Australia's Heard Island and McDonald Islands (HIMI) Marine Reserve has been approved by the Federal Government.

The *HIMI Marine Reserve Management Plan 2014–2024* covers about 71 000 km² of terrestrial and marine areas and has a strong focus on biosecurity and waste management.

The new plan includes 6200 $\rm km^2$ of high conservation waters, supporting distinct benthic habitats, species and ecosystems, added to the Reserve in March this year.

HIMI is located about 4000 km south-west of mainland Australia in the southern Indian Ocean. The islands are Australia's largest International Union for Conservation of Nature 1a Strict Nature Reserve and home to Australia's only active volcano, Big Ben, rising 2745 m above sea level.

The new *HIMI Marine Reserve Management Plan 2014–2024* has been released.



King penguins on Heard Island

Threat Abatement Plan for seabirds

The Threat Abatement Plan 2014 for the incidental catch (or bycatch) of seabirds during oceanic longline fishing operations was released in August. The Plan has been developed to address the key threatening process of 'the incidental catch (or bycatch) of seabirds during oceanic longline fishing operations', which is listed under the *Commonwealth Environment Protection and Biodiversity Conservation Act 1999* (Cth). The Plan varies the Threat Abatement Plan 2006.



Black-browed albatrosses such as this one, are affected by oceanic longline fishing in the Australian Fishing Zone. The Plan is a feasible, effective and efficient approach to abating the threat to Australia's seabird biodiversity during oceanic longline fishing operations. The goal of the Plan is to achieve zero bycatch of seabirds, especially threatened albatross and petrel species, in

all longline fisheries. The Plan binds the Commonwealth and its agencies in responding to the impact of longline fishing activities on seabirds, and identifies the research, management and other actions needed to reduce the impacts of the key threatening process on affected seabird species. The Plan will be reviewed within five years.

JONATHON BARRINGTON Senior Policy Adviser, Australian Antarctic Division

Antarctic medal for a lifetime of international policy work

An expert in Australian Antarctic policy has been awarded the 2014 Australian National Antarctic Research Expedition's (ANARE) Phillip Law Medal.



Andrew Jackson received the award for his outstanding contribution to Antarctic affairs and the Antarctic community, particularly for his leadership and achievement in the field of international Antarctic Policy.

Mr Jackson worked for the Australian Antarctic Division for 31 years in a variety of roles including as General Manager of Policy, Head of Australia's delegation to the annual Antarctic Treaty Committee Meeting, and as an Antarctic

Andrew Jackson, winner of the 2014 Phillip Law Medal.

voyage leader. After his retirement from the Antarctic Division in 2009 Mr Jackson served as the Head of the Host Country Secretariat for the 2012 Antarctic Treaty Consultative Meeting in Hobart, which was attended by more than 300 delegates from over 50 nations.

The Phillip Law Medal was established in 2011 to celebrate the life and achievements of Dr Phillip Garth Law, the ANARE Club's founder and patron. Dr Law was founding Director of the Australian Antarctic Division from 1949 until 1966.

When the night comes

Former Australian Antarctic Arts Fellow, Favel Parrett, published her second novel, *When the night comes*, in August 2014. The book tells the story of a young girl, her brother and their mother, after they move to Hobart and make friends with one of crew of the former Antarctic resupply ship, *Nella Dan*.

The book is the direct result of an Arts Fellowship to Davis station in 2012, to assist Ms Parrett in her research about the *Nella Dan*. Before her fellowship, Ms Parrett interviewed many past crew and expeditioners who travelled on the *Nella Dan*.

Syd Kirkby's biography

In October, former Australian Antarctic Arts Fellow Lynette Finch, published the first full biography of Syd Kirkby, an extraordinary modern day explorer who mapped vast tracts of Antarctica.

Fixing Antarctica: Mapping the Frozen South tells the story of the surveyor and explorer, who began his Antarctic journey at Mawson in 1956, spending 15 months with 14 other



NAME AND ADDRESS OF

PHOTO: HACHETTE AUSTRALIA

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scientists on the isolated rock outcrop at the edge of the Antarctic plateau. Over the next 20 years Syd Kirkby explored and mapped more unknown regions in the world than any other person in history.

Ms Finch travelled to Mawson in 2008 to gain a sense of place to better explain her subject. *Fixing Antarctica* is told through interviews with Syd's contemporaries, personal diaries and the diaries of other Antarctic explorers.

Southern Ocean Symphony



A 45 minute symphony inspired by the science of climate change in the Southern Ocean has been released on CD. The symphony, *ex Oceano – we are from the ocean – the ocean sustains us*, was written by Tasmanian composer Matthew Dewey in response to a series of essays and research by former Australian Antarctic Division/Institute for Marine and

Antarctic Studies (IMAS) PhD student, Rob Johnson, and IMAS/CSIRO PhD student Nick Roden. The symphony was recorded last year by the Czech National Symphony Orchestra in the Rudolfinum Concert Hall in Prague. Copies of the CD are available from Music Without Frontiers in Hobart, iTunes and cdbaby. An online CD booklet is also available from the Lynchpin website http://www.lynchpin.org.au/. The booklet includes an overview of the science that inspired the composer. A preview of the recording of the symphony, filmed by Nick, is available online at vimeo.com/80873449.

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FREEZE FRAME

MEG MCKEOWN works as an Antarctic Medical Practitioner for the Polar Medicine Unit at the Australian Antarctic Division. She was a small animal veterinary surgeon for 12 years before graduating from human medicine in 2009. She is currently completing her Fellowship with the Australian College of Rural and Remote Medicine. Since 2012 Meg has worked as the doctor at Casey and Macquarie Island, as ship's doctor on several voyages on board Government ships, and at the Polar Medicine Head Office during resupply. There are many opportunities for landscape photos on Macquarie Island but the real thrill for me is to photograph the wildlife in action. This photo was taken on West Beach, about 15 minutes walk south from the station along the coast. I happened across a recently deceased mature male elephant seal in the water and the giant petrels were in great numbers as they took on their role as vultures of the island. This southern giant petrel was one of almost 100 birds that were on the beach or close by in the water, working on cleaning the carcase. It was a brutal scene, but mesmerising and I realise part of the cycle of nature here on Macquarie Island.

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