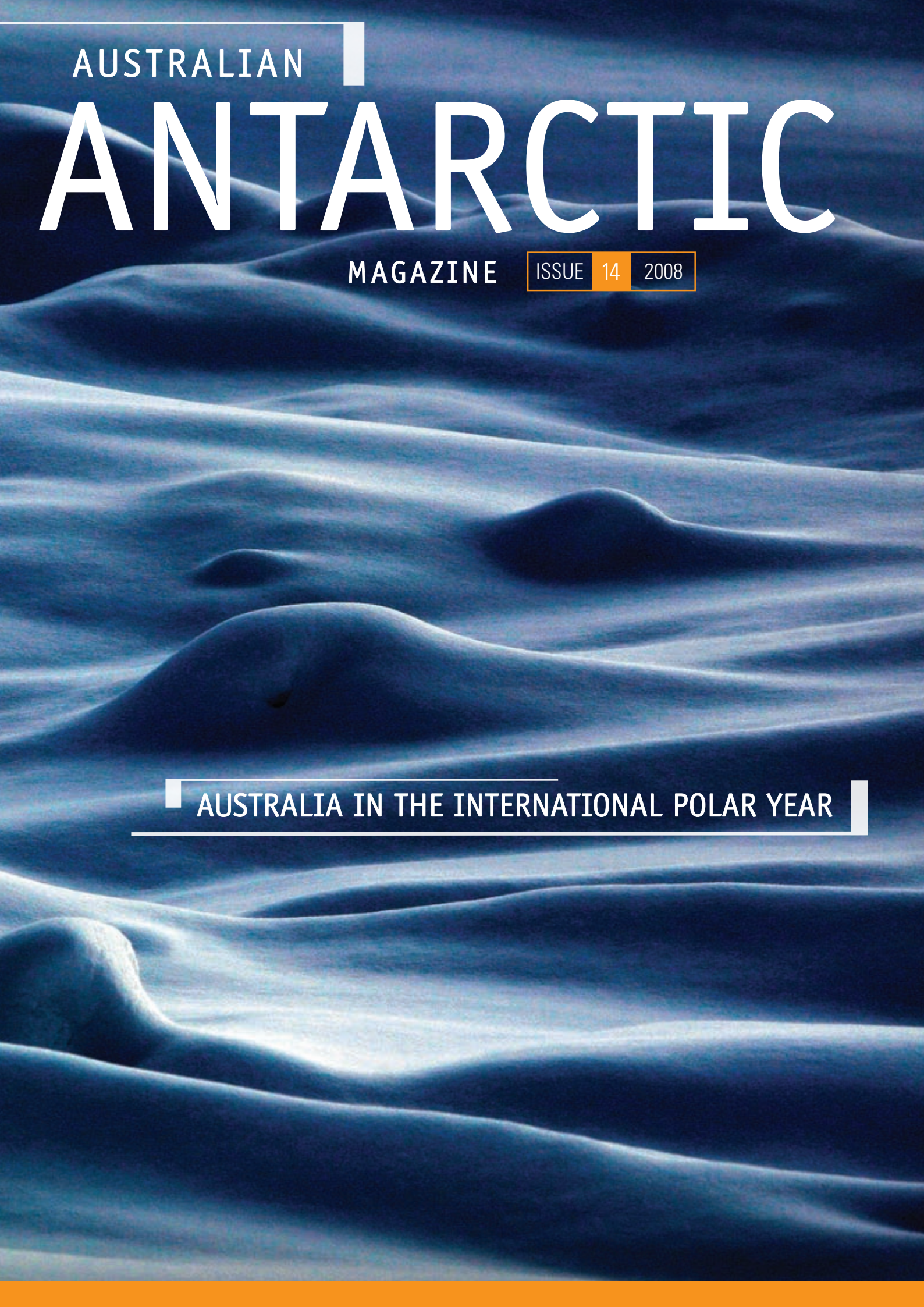


AUSTRALIAN ANTARCTIC MAGAZINE

ISSUE 14 2008

AUSTRALIA IN THE INTERNATIONAL POLAR YEAR

AUSTRALIAN
ANTARCTIC
MAGAZINE

ISSUE 14 2008

CONTENTS

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

Australia's four Antarctic goals are:

- To maintain the Antarctic Treaty System and enhance Australia's influence in it;
- To protect the Antarctic environment;
- To understand the role of Antarctica in the global climate system; and
- To undertake scientific work of practical, economic and national significance.

Australian Antarctic Magazine seeks to inform the Australian and international Antarctic community about the activities of the Australian Antarctic program. Opinions expressed in *Australian Antarctic Magazine* do not necessarily represent the position of the Australian Government.

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

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

Editor: Wendy Pyper

Editorial Advisory Committee: Sally Chambers, Andrew Jackson, Professor Michael Stoddart
Production: Jonothan Davis, Jessica Fitzpatrick, Glenn Jacobson, Chris Clarke

Graphic Design: Red Jelly

ISSN 1445-1735 (print version)

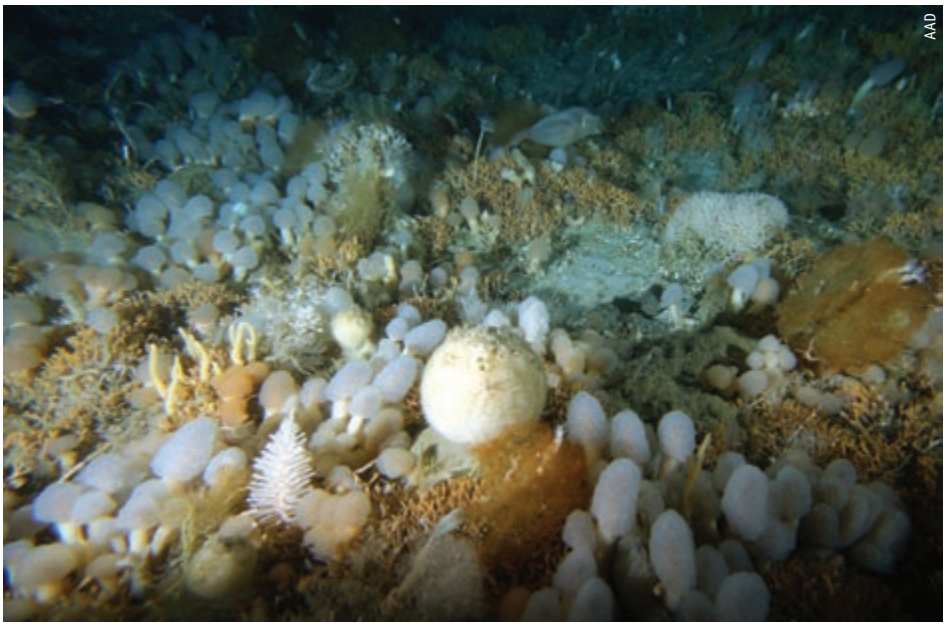
Australian Antarctic Magazine can be viewed online: <http://www.aad.gov.au/magazine>.

Australian Government
Department of the Environment, Water, Heritage and the Arts
Australian Antarctic Division

FRONT COVER: CHRIS WILSON
Fresh midwinter snowfall over rocks at Casey station.

AUSTRALIA IN THE INTERNATIONAL POLAR YEAR

Australian Antarctic research made huge advances and exciting new discoveries in the first season of the International Polar Year (IPY). The IPY officially runs from March 2007 until March 2009, to enable one full year of research to be conducted at both poles.


AAD

A trawl-mounted camera captured the amazing biodiversity of Southern Ocean sea-bed life during the Collaborative East Antarctic Marine Census. This image shows, among other things, white, mushroom-shaped sea squirts (Ascidians), a round sponge with a brittle star attached to it, a white, pine-tree-shaped soft coral, and scattered throughout, orange, branching 'moss animals' (Bryozoans).

This issue of the *Australian Antarctic Magazine* features just some of the research conducted for two of Australia's major IPY projects – the Collaborative East Antarctic Marine Census (CEAMARC) and the Sea Ice Physics and Ecosystem eXperiment (SIPEX).

New species and remarkable communities were discovered during the CEAMARC flagship voyage for the Census of Antarctic Marine Life, which is investigating the distribution and abundance of Antarctic marine biodiversity to provide, among other things, a reference point from which to monitor the impact of future environmental and climate change. Three ships combed a region adjacent to Dumont d'Urville in East Antarctica, surveying pelagic (open ocean) waters and the sea-bed up to 2100 m depth. The combination of traditional sampling gear and cutting-edge imaging technology revealed many surprises – from giant jellyfish, sea spiders and marine worms, to tiny and exquisitely formed zooplankton. Many species were new to the researchers involved and may even prove to be new records for the region and for science. Pages 2-13 cover some of the research and other projects conducted as part of CEAMARC and reveal the amazing diversity of life that survives under extreme conditions.


RUSS HOPCROFT

This 4 mm long 'copepod' of the genus Euaugaptilus, *collected during the Collaborative East Antarctic Marine Census, is a common component of the deep zooplankton. Copepods are crustaceans, like krill, and an important food source for higher organisms.*

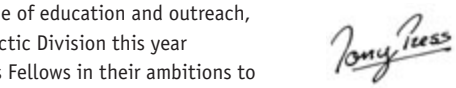
The SIPEX voyage provided the first opportunity for Australia to study the Antarctic sea ice zone in early spring – the period of maximum sea ice extent. The multi-disciplinary experiment studied the physics and biology of the sea ice, and the interactions and dependencies of the ice structure, thickness and snow properties and their effects on the under-ice algae and ecosystem of the Southern Ocean. The articles on pages 14-19 look at some of the research conducted during SIPEX and the education and outreach opportunities embraced by two Tasmanian teachers who joined the voyage. The pair helped scientists to share their work with students and teachers around the world – an initiative strongly endorsed for all IPY projects.

Continuing the theme of education and outreach, the Australian Antarctic Division this year supported three Arts Fellows in their ambitions to promote Antarctic people and places through their various mediums; pages 32-34 tell their stories.

A range of other IPY-related projects were also supported this year including atmospheric research at Davis, which provided the first observations of noctilucent clouds in the Southern Hemisphere using satellite and ground-based radar and lidar measurements simultaneously (page 29).

Notable also was the extraction of an ice core from Law Dome for analysis of a short-lived radio-isotope (page 24). This research was made possible by the historic introduction of the first passenger flights of the Airbus A319 between Hobart and Australia's Wilkins Runway in January (page 23). The aircraft enabled researchers to fly the ice core back to Australia in time to record the short-lived beryllium-7 signature – a feat previously not possible because of the lengthy sea journey. As noted by both the Governor General (during the opening of the Wilkins Runway) and our new Environment Minister, Peter Garrett, the air link opens up new opportunities for research in Antarctica.

There is more IPY-related research than there are pages in this magazine, but future issues will continue to update you on the important work this significant year has set in train.



AJ PRESS
Director, AAD

RUSS HOPCROFT

UNDERWATER WORLD GIVES UP ITS SECRETS

Giant sea spiders, jellyfish and marine worms were among the many surprises encountered by scientists during the Collaborative East Antarctic Marine Census (CEAMARC), conducted recently as part of the International Polar Year (IPY) Census of Antarctic Marine Life.

The census involved ships supported by four nations – Australia (*Aurora Australis*), France/Belgium (*L'Astrolabe*) and Japan (*Umitaka Maru*) – surveying transects in the Southern Ocean adjacent to Terre Adélie and George V Land in Antarctica.

While the *Umitaka Maru* and *L'Astrolabe* focussed on the pelagic (open ocean) realm, the *Aurora Australis* focussed on the sea-bed communities of the survey region (see story page 4). Common sites were sampled by all three vessels on the continental shelf. *Umitaka Maru* also surveyed sites north of the continental shelf to look at north-south distribution patterns, and the deep pelagic zone – a poorly sampled habitat known to have a high biodiversity of zooplankton and jellyfish.

Scientists aboard the *L'Astrolabe* sampled the inshore plankton of the area using a standard 'WP2' plankton net. This is a small net (0.25 m^2 mouth area) with 200 micron (0.2 mm) mesh that is ideal for collecting small zooplankton and very young fish larvae. The team also conducted CTD (conductivity-temperature-depth) casts which measured the profiles of temperature, salinity and other physical properties in the water column. Bottles attached to the CTD frame collected water for studying phytoplankton and other micro-organisms that provide food for the zooplankton. While the *L'Astrolabe* survey was perhaps more routine, it provided continuity with past French surveys in the area.

The *Umitaka Maru* conducted a more detailed survey using a range of traditional sampling gear supplemented with a new, innovative Visual

This cranchid squid larva is only 10 mm long but adults can grow up to 2 m in size. The bodies of these squid remain translucent.

Japanese scientists measure the pelagic fish Pleuragramma antarcticum *(Antarctic herring).*

The Norpac net, consisting of 330 micron and 110 micron nets side by side, was used to study all sizes of plankton.

Plankton Recorder (VPR) developed by Dhugal Lindsay of the Japan Agency for Marine-Earth Science and Technology. The VPR has both high resolution still cameras and a high definition video camera to capture images of plankton swimming in their natural state.

In addition, CTD and bottle casts provided data on the physical and chemical properties of the water. Phytoplankton collected from the bottles were placed in incubation chambers to determine how quickly they grew and therefore how much food they would provide for zooplankton, which in turn support higher trophic groups such as fish, birds and mammals. A WP2 net and a 'Norpac' net, which consists of 330 micron and 110 micron nets side by side, were used to study all sizes of plankton.

The *Umitaka Maru* also used two large survey nets, cast to depths of up to 2000 m. A Rectangular Midwater Trawl net system was used to collect krill larvae and adults, small zooplankton (meso-zooplankton), larger macro-zooplankton and small fish. An International Young Gadoid Pelagic Trawl net was used to survey pelagic fish, such as the Antarctic herring (*Pleuragramma antarcticum*), as well as lantern fish, other small mid-water fish species, squid, and large jellyfish.

Both large survey nets produced many good quality specimens that were used by Canadian zooplankton biologist, Russ Hopcroft (*Australian Antarctic Magazine* 12: 28), to take high quality photos (pictured). The photos were taken with a high definition camera/microscope system and image capturing software. The whole system was mounted in such a way as to eliminate the vibration from the ship.

The still camera on the VPR allowed us to take quality images of plankton as small as a few millimetres. The VPR video system also provided 80 minutes of continuous footage, displaying both the natural colours and behaviour of plankton, as well as larger organisms, such as fish and huge jellyfish. Most plankton and gelatinous zooplankton captured in nets end up in poor condition or badly damaged. All usually change colour or die soon after reaching the deck, or become distorted after preservation. Seeing plankton alive in their natural state gave a completely different appreciation of the beauty and diversity of their shape and form.

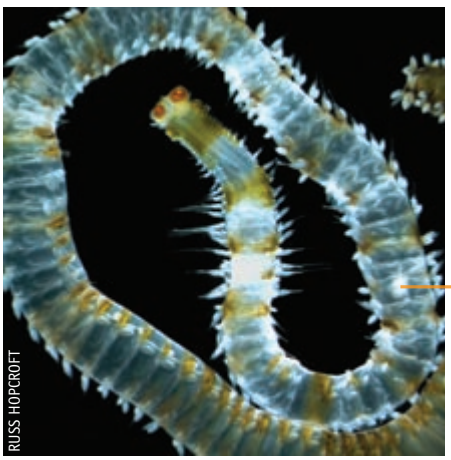
Many of the jellyfish captured were new to the researchers and may be new records for the region. Tissue was taken for genetic analysis, to help determine if we have any previously undescribed species. A notable result of the voyage was the high abundance and diversity of jellyfish in the deeper waters down to 2000 m. Large specimens of *Stygiomedusa* were collected in near-perfect condition. These jellyfish have large bells and tentacles that extend 6-8 m in length. While we need to compare the results with past data, the collective memory of experienced Antarctic biologists on board suggests that the jellyfish are more abundant than before.

We've planned the survey and collected the samples and associated environmental data. The next task is to pull all the information together and address a range of questions such as: have the deep water zone communities changed and will this have an effect on the rest of the ecosystem? Meetings of key CEAMARC personnel are now in train, to begin collating results and building a picture of the biodiversity and ecosystem processes in the survey area.

GRAHAM HOSIE
CEAMARC leader, AAD

More information:

To view the ships' tracks, 'situation reports' from all three voyages, other daily reports, videos and photos, visit the Census of Antarctic Marine Life website: www.caml.aq and the CEAMARC expedition site http://mersaustrales.mnhn.fr/rubriques/voir/15 (in French and English).



This marine worm or 'pelagic polychaete' is made up of segments, each of which has a pair of fleshy protrusions called parapodia that bear many bristles. The parapodia are used for movement and respiration.

SHIP'S LOG: COLLABORATIVE EAST ANTARCTIC MARINE CENSUS

On board the *Aurora Australis*, Voyage Leader, **Dr Martin Riddle**, captured the excitement of the CEAMARC sea-bed surveys in his 'situation reports'. The voyage also supported another Australian-led International Polar Year project – Climate of Antarctica and the Southern Ocean (CASO).

DATE: 21/12/07 POSITION: -62 48E, 142 51S
ICE CONDITIONS: nil

In transit to the main sampling area for both CEAMARC and the southern CASO sites. The third Continuous Plankton Recorder tow is currently in the water. Yesterday afternoon the first bulk seawater sample was collected for metagenomic analysis[1] using techniques based on those developed for sequencing the human genome.

DATE: 23/12/07 POSITION: -65 59E, 142 39.6S
ICE CONDITIONS: 2/10 loose pack ice

The ship is now doing scientific activities around the clock with most people working 12 hour shifts. At 0715 we deployed the first of the CEAMARC sampling equipment at site 27; the very robust epibenthic sled, which collects the top layer of sea-bed and anything living in it.


MARGOT FOSTER

The team spent many hours sorting each catch.


SANDRA POTTER

Deployment of Conductivity, Temperature and Depth (CTD) sampling bottles.

The first organism to be photographed, tagged and bagged was an octopus. The sled contained enough sea-bed animals to keep a large team happily sorting for several hours – 'zoot alors! qu'est-ce que c'est?' We have since collected a CTD (conductivity-temperature-depth) water sample and used the box-corer to collect a relatively undisturbed sample of the sea-bed sediment. We have tested the procedure for deploying the beam trawl and are fine tuning the information read-out which tells us how much winch wire has been paid out and the tension on the wire. The next deployment will be the Geosciences Australia sea-bed camera so that we can see what the animals look like in their undisturbed habitat.

DATE: 25/12/07 POSITION: -66 20E, 143 17S
ICE CONDITIONS: distant icebergs

Having tested a range of samplers at the first sites, we are now focusing our efforts on those that proved most effective. The combination of samplers that we are now using is giving us a broad representative sample of the full suite of sea-bed animals, including excellent very high definition still photographs from the trawl-mounted camera system. The team of designers and builders in the Australian Antarctic Division's Science Technical Support section are to be congratulated for their combined skills in producing rugged equipment that works under very difficult conditions[2]. A highlight of today's hauls has been the first solitary corals for the trip. The skeletons of these animals are made from aragonite – the form of calcium most susceptible to ocean acidification. The specimens collected today were from 700 m and had very delicate, friable shells. It will be interesting to see whether they are found at the deeper sites where, because of the increased water pressure, the aragonitic calcium will have a greater tendency to dissolve. Oh yes....and Happy Christmas to everyone.

DATE: 28/12/07 POSITION: -66 33S, 143 19E
ICE CONDITIONS: continent in sight

We are sampling in some very dramatic country. One trawl last night was taken from the lip of a very steep drop-off, going from 130 m depth to more than 400 m in a very short distance. Although the trawl was on the sea-bed very briefly, it came up with a good haul of giant sponges and fish, indicating an area of very high production. As we move into some of the deeper sites we are beginning to see the first of the giant crustaceans which are characteristic of the Antarctic. Overnight we caught amphipods that were 5 cm long and isopods more than 8 cm long – these groups include the sand-hoppers and sea-slaters which, around the coast of Australia, are usually less than a centimetre long. We have completed 20% of our sampling stations.

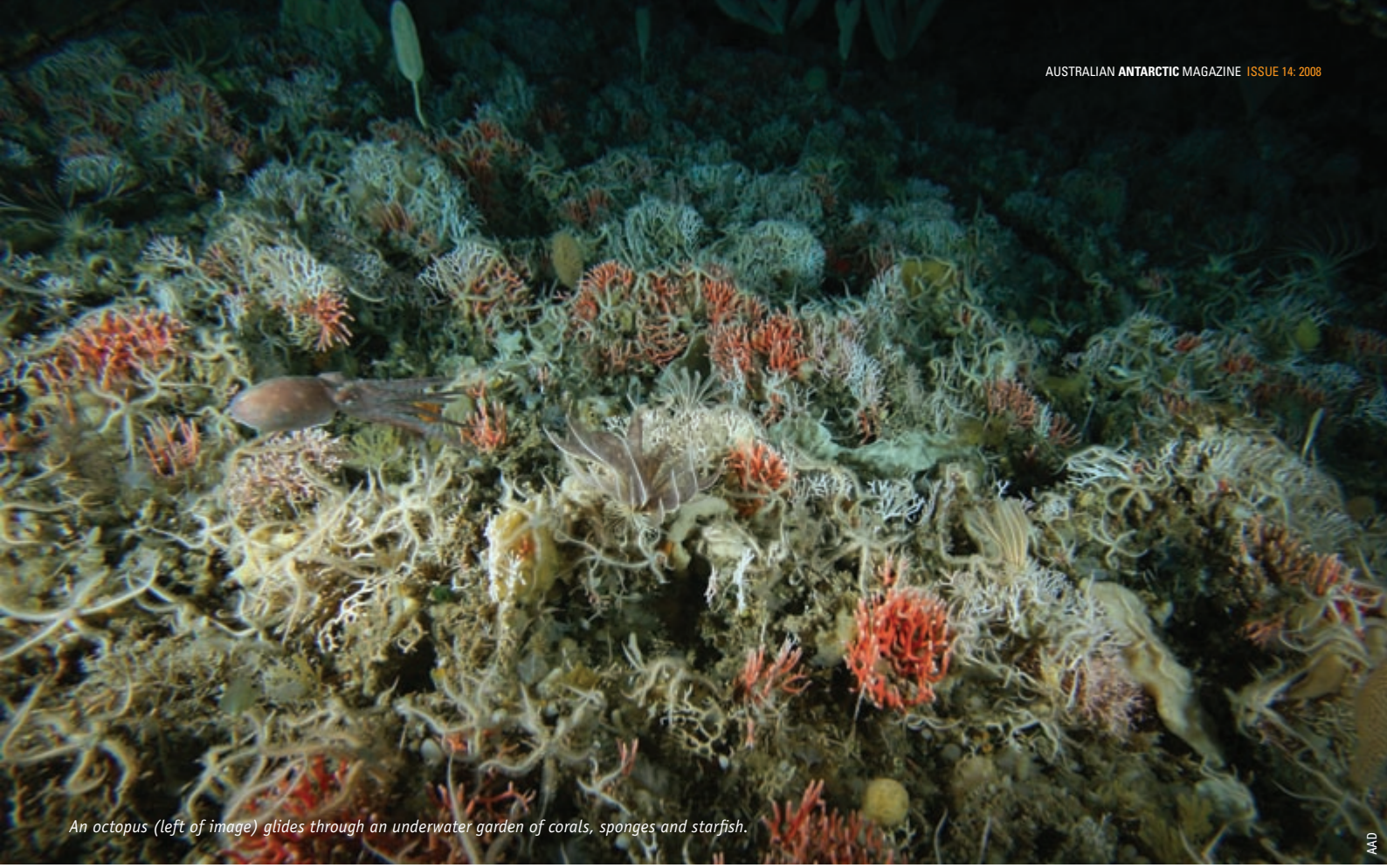
DATE: 03/01/08 POSITION: -66 34S, 144 41E
ICE CONDITIONS: distant icebergs

After riding out 40 to 50 knot winds for the first day and a half of the New Year, conditions had abated sufficiently by 1600 hrs yesterday to allow sampling to re-commence. Overall impressions of the sea-bed invertebrate communities are that the diversity and species composition on the Adélie Bank seems roughly equivalent to that known from at Dumont D'Urville at shallower depths (40-200 m), but tends to decrease in Commonwealth Bay, possibly because of increased iceberg scouring. Two stations (38 and 36) show strikingly different benthic communities compared to surrounding stations, with many anemones,


AAD

Giant glass sponges from the Antarctic can grow to 1.5 m tall.

1 See story page 8. 2 See story page 12.



An octopus (left of image) glides through an underwater garden of corals, sponges and starfish.

AAD

synascidians and serolid isopods. These stations are situated well beneath the action of icebergs at the bottom of the Georges V Basin where water conditions may play a role in shaping very different assemblages. The multi-beam data, previously collected in this area by the US research vessel the *Nathaniel Palmer*, provides a very detailed picture of the sea-bed, including tracks of past iceberg scouring[3]. The data is proving invaluable for interpreting the relationship between the living communities and the physical environment of the sea-bed.

DATE: 04/01/08 POSITION: -66 19S, 143 59E
ICE CONDITIONS: isolated bergs

The big isopods, amphipods and sea-spiders of the past few days were put firmly in their place last night by the arrival of the Big Polychaete. This magnificent scale-worm was about nine inches (230 mm) long, 3.5 inches (90 mm) across, with scales more than one inch (24 mm) in diameter and weighed about 330 gm – at just three to the kilo this is by far the largest polychaete seen by any of the benthic ecologists on board. We have since captured video imagery of these monsters scurrying along the sea-bed as the trawl approaches. To top it off, the scale-worms arrived complete with their own over-size parasitic nematodes (up to 4 inches long) infesting the space under the scales.

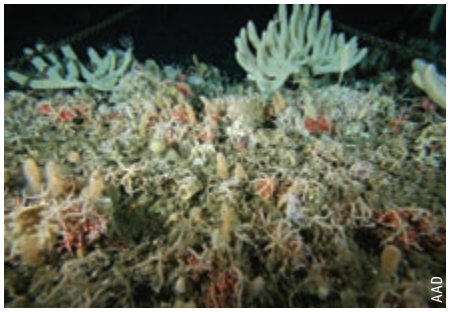
DATE: 06/01/08 POSITION: -65 39.6S, 143 02.4E
ICE CONDITIONS: isolated bergs, bergy bits

We all expected the Big Polychaete to be the undisputed highlight of the voyage, however, the Southern Ocean continues to turn-up surprises. Yesterday, while sampling the transect from 400 m to 2100 m down the shelf, we blew out the trawl net as we tried to bring it on deck after sampling the 800 m site. The video footage from the trawl-mounted camera explained why. Almost the entire day shift crammed into the electronics cupboard to see the footage and, after the first gasps of 'incroyable!', watched in hushed awe as a scene rivalling the best parts of the Great Barrier Reef was revealed. The sea-bed was 100% covered with living material – colourful branching coralline species and gorgonians forming the major lower storey structure and large branching sponges the upper storey. Amongst this were numerous sea-stars, sea-cucumbers, crustacea and fish of types at yet unseen. After repairing the trawl nets we returned to re-sample the site, this time being very cautious with the time allowed for the trawl to be on the bottom, and were rewarded with a relatively small catch, but with many species not previously collected. In marked contrast the communities at 1600 m and 2100 m were rather sparse, with much un-colonised rock and

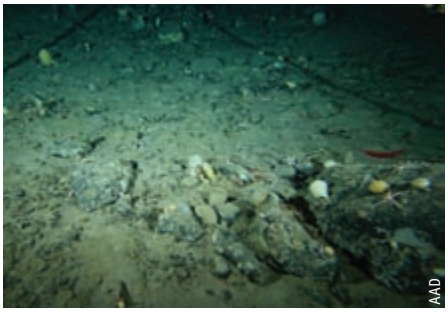
AAD

At 23 cm long, 9 cm wide and 330 gm in weight, this scale-worm was far larger than any previously seen by the biologists on board.

3 See story page 7.



At 800m on the edge of the continental slope a reef of cold water corals, gorgonians and sponges provided a habitat for a rich community, including fish, crustaceans and sea stars.



Biodiversity between 1600 and 2000 m was sparse in comparison to shallower depths with much bare rock. But even at these depths species new to the survey were found, such as the dark red deep sea prawn (right).

The trawl-mounted camera designed by the Australian Antarctic Division's Science Technical Support team provided CEAMARC with tantalising video footage of the sea-bed.

coarse sediment visible, but again the samples, although small, contained many species new to us. The deck crew must be congratulated for their skill and persistence in successfully sampling these very difficult environments, without which the scientists would have nothing. We have now commenced the main CASO (Climate of Antarctica and the Southern Ocean) sampling for the voyage.

DATE: 13/01/08 POSITION: -66 03.7, 141 17.7E
ICE CONDITIONS: large icebergs, open water

Yesterday's samples from 400 m, 800 m and 1100 m were an interesting contrast to those from a similar depth series which, at 800 m, was dominated by a colourful garden of filter-feeding coralline species. Yesterday's 800 m site had a very sparse covering of surface-living filter-feeders, such as sponges and bryozoans, but had very large numbers of *Macrourus whitsoni* or rat-tails, a common fish from these depths throughout the world. The sea-bed photographs indicated a lot of 'marine snow' (organic particulates) in the water and a piscean wall of mouths – fish waiting on the sea-bed for food to be washed past them by the currents. So although only 20 miles apart and sharing the common characteristics of very high productivity and biomass, the benthic fauna at these sites were intriguingly different.

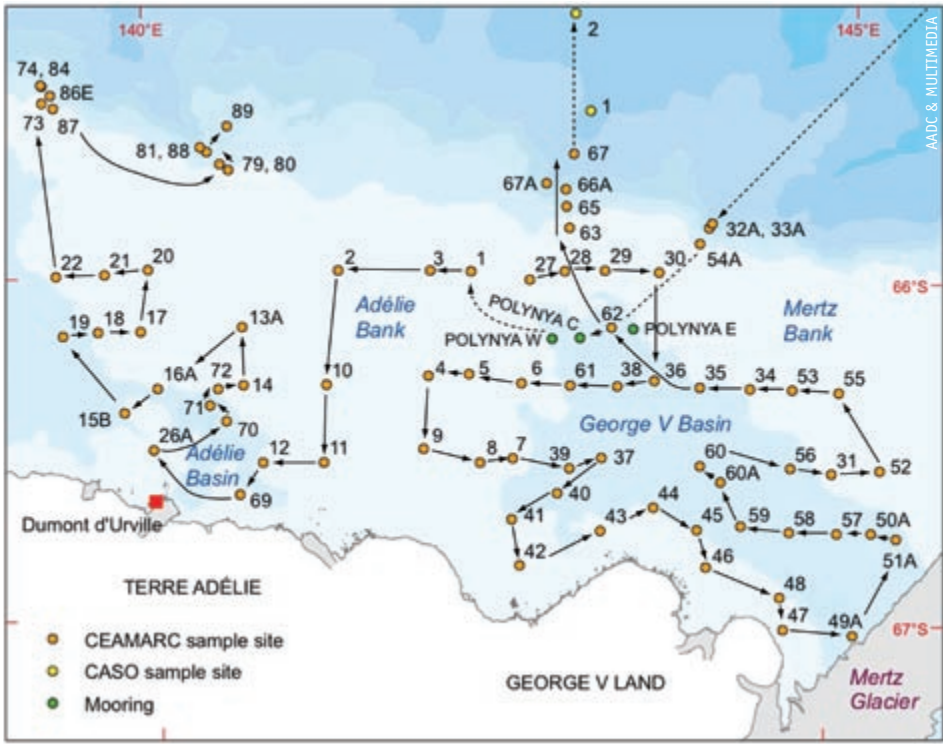
DATE: 19/01/08 POSITION: -65 37, 141 04.3E
ICE CONDITIONS: large iceberg, bergy bits, growlers

As predicted, sampling the very rugged sea-bed in this canyon system at the edge of the continental shelf has been difficult. At the cost of some torn trawl nets, we have managed to get imagery and samples down to 1500 m, with the very diverse sea-bed offering up a similarly diverse fauna. Last night we recorded the most fish species from any one trawl – 16 including at least one which was new to this survey. The benthic invertebrates were similarly diverse with a great range of sedentary groups, such as sponges, bryozoans (lace coral), tunicates (sea squirts), gorgonians and some very large solitary corals, forming the main supporting structure for an equally diverse variety of mobile groups such as polychaete worms, amphipod crustaceans, ophuroids (brittle stars), crinoids (feather stars), echinoids (sea urchins), asteroids (sea stars), pycnogonids (sea spiders) and a range of molluscs. Early this morning we stopped the benthic work temporarily and switched our efforts to sampling the waters around the very large iceberg nearby, with the intention of identifying whether it is a source of trace nutrients that might stimulate plankton growth. Satellite imagery indicates the iceberg is about 35 km long by 18 km wide. The berg is designated B-17A and came into this region in October 2006 from a large chunk of the Ross Ice Shelf that calved in April 2000.

DATE: 20/01/08 POSITION: -65 24.7, 139 50.7E ICE CONDITIONS: open water

Yesterday water samples were collected from seven sites at a range of distances from the large iceberg using the Fast Rescue Craft. While sampling was happening, the *Aurora Australis* maintained its position down-wind and down-current to ensure there was no risk of the ship contaminating the surface waters. These samples are to be analysed for ultra-low levels of trace elements and even the presence of the ship's hull in the immediate sampling area could compromise the results[4]. The CEAMARC sampling officially finished at 12:08 am. Overall, 82 different sites were occupied during CEAMARC, with samples collected from at least 78 sites; well in excess of the 67 sites we had hoped for. Everyone involved is to be congratulated for putting in an enormous and sustained effort to achieve such an excellent result.

MAP NO. 13475



CEAMARC and CASO sampling stations. Sampling for CEAMARC began at site 27 and concluded at site 67, when work for CASO began. CEAMARC sampling recommenced about one week later at site 1.

More information:

To read the full sitreps visit www.caml.aq and click on the *Aurora Australis* link.

See also: www.aad.gov.au/default.asp?casid=34320 and http://mersaustrales.mnhn.fr/rubriques/voir/15

4 See story page 20.

SOUND DECISIONS FOR SEA-BED SAMPLING

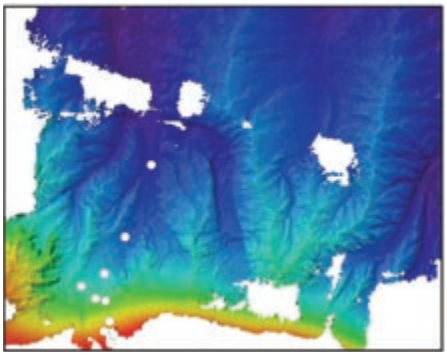
High-resolution three-dimensional (3-D) maps of the sea-bed gave researchers a new window into the deep during the recent Collaborative East Antarctic Marine Census (CEAMARC).

The 3-D maps of the sea-bed offshore of Terre Adélie and George V Land, were generated using the latest multibeam sonar data collected by previous research voyages to the region. The maps provided an accurate picture of the depth and shape of the sea-bed, allowing scientists to precisely target the sea-bed with their sampling gear.

Multibeam or 'swath' sonars are advanced echosounders mounted on ships to accurately map vast areas of the sea-bed. Unlike the more familiar 'singlebeam' echosounders, which transmit a single, narrow sound pulse directly under the vessel, multibeam echosounders transmit a wide fan of sound either side of the ship and receive multiple beams of sound reflected off the sea-bed. Each beam represents an individual 'sounding' or depth point. As the fan of sound can have a spread of up to 75 degrees either side of the vessel, and transmits hundreds of times a second, the result is a detailed 3-D picture of the sea-bed made up of millions of individual soundings.

The sea-bed data collected by multibeam sonar can be as good as anything seen on land using satellites. Depending on the depth of the water, the technology can detect features as small as a brief case and has been a vital tool in detecting vulnerable marine ecosystems, such as seamounts, cold water corals, submarine vents, and even shipwrecks and other artificial structures. In Antarctica, multibeam has been used to map iceberg scours and deep glacial trenches, and to detect undersea moraines left by retreating glaciers.

The multibeam data, which is archived in digital files at Geoscience Australia, were combined in 3-D visualisation software and a rainbow colour applied to the final surface, according to depth. Red to yellow colours represent shallower depths and blue to violet colours represent deeper depths. The surface was also given artificial sun shading to provide shadows, which highlight any relief or bumps on the sea-bed. The visualisation software is used to fly through the seascape or simply provide plan-view maps for use in a geographic information system.

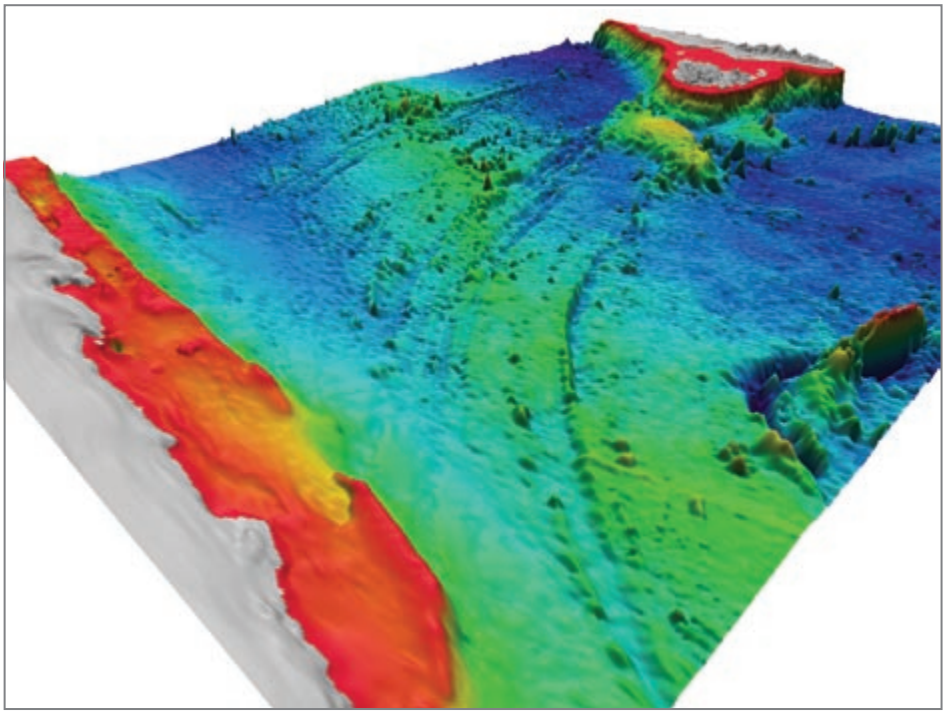


A 90km-wide plan-view of the 3-D seascape in the CEAMARC study area. The circles are sample sites targeting the deep and rugged submarine canyons draining the George V shelf. White patches indicate areas where multibeam data is missing. The shallower continental shelf is coloured red to yellow.

For the CEAMARC voyage to the Terre Adélie and George V Land shelves, the 3-D underwater landscape or 'seascape' maps were used to give precise locations for sampling different underwater habitats and provide a geological context to the survey area. For example, in the George V Basin – an approximately 1300 m-deep glacial trough on the shelf – maps show long 'megaflutes', or scours, from the passage of the Mertz Glacier. Underwater cameras precisely targeted the megaflutes and found a seascape that looked like rolling dunes, where most of the attached fauna was concentrated along the ridge tops.

Another example was submarine canyons, which had deeply incised the continental slope to drain sediments and Antarctic bottom water off the shelf. Researchers were able to precisely drop cameras, trawls and oceanographic instruments into the canyon axes to record the marine life and environment in these very rugged features. The random, shallow scours left by icebergs on the shallower bank tops could also be seen in the 3-D seascapes, and cameras towed over the scours showed the dramatic contrast between the undisturbed marine life outside the scours and what remained in the scours after the icebergs had left.

The 3-D seascape maps were invaluable decision-making tools for the CEAMARC survey. However, the benefits of multibeam surveys extend beyond sea-bed sampling and include safer navigation charts around our Antarctic stations. Presently, Australia must rely upon other nations to do their multibeam surveys, as none of Australia's polar research vessels have multibeam systems fitted. These advanced instruments are a standard instrument on other nations' ships, including New Zealand, and are being used in numerous ways for environmental and safety purposes.



An oblique-view of the 3-D seascape between Tasmania and Antarctica, showing the deep scours and numerous seamounts marking Australia's separation from Antarctica after the breakup of Gondwana. Macquarie Island sits on a tall ridge on the right of the image. The seascape used bathymetry data from satellites, singlebeam echosounders and multibeam sonar. Grey colours show the land or icecap above mean sea level, and rainbow colours represent the variation in water depth from shallow shelf areas to the deep trenches.

ROBIN BEAMAN
School of Earth and Environmental Sciences, James Cook University

SEQUENCING SECRETS OF WHOLE MICROBIAL COMMUNITIES

For the first time whole microbial communities and their functions, in Antarctica and the Southern Ocean, are being examined using DNA sequencing technology.

Dr Rick Cavicchioli and his colleagues from the University of New South Wales, and collaborators at the J. Craig Venter Institute and the US Department of Energy Joint Genome Institute, are using 'metagenomics' to sequence the DNA in entire environmental samples, rather than the traditional method of sequencing the genomes of single, cultured species. This approach will not only provide the scientists with a more rapid and expanded view of microbial diversity and function in the southern polar region, but will set a precedent for the capacity to use the technique on Antarctic and Southern Ocean samples.

'The southern polar region plays a critical role in maintaining microbial processes that are essential for the health of the world's ecosystems, yet we know very little about them,' Dr Cavicchioli says.

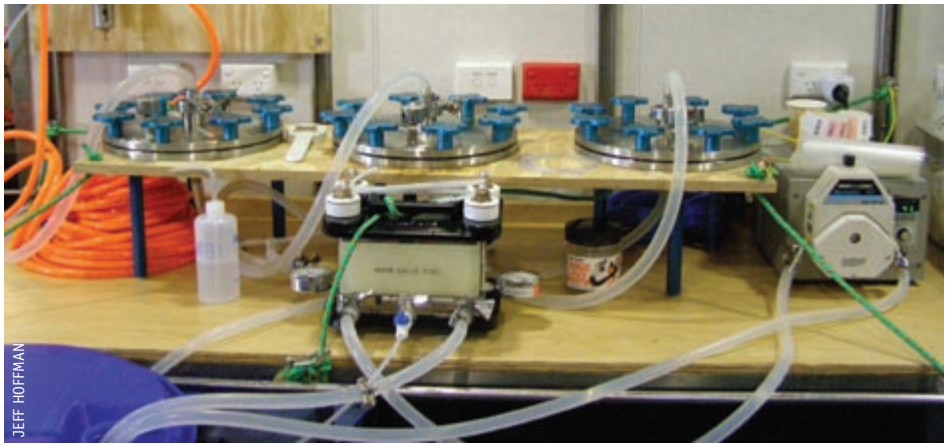
'Metagenomics offers an unprecedented means to reveal the secrets of Antarctic and Southern Ocean microorganisms and to learn about the unique, cold-adapted processes that they perform and their ability to adapt to global warming.'

About 75% of the earth's biosphere is cold and 'psychrophiles' (cold-loving organisms) can be found in permanently, seasonally and artificially (such as refrigerated) cold environments. However, the functional role of psychrophilic microbes in cold environments – such as the processing or organic and inorganic carbon and nitrogen compounds – has only recently been appreciated.

To help address this knowledge gap Dr Cavicchioli and his team collected 25 surface and deep-water samples (from 1.5 - 3693 m) from the Southern Ocean during the Collaborative East Antarctic Marine Census (CEAMARC) earlier this year. These, and other samples collected over the next five years, will provide a basis for examining the genomic composition of bacteria and archaea (an ancient group of microbes). The team will also use 'metatranscriptomics' and 'metaproteomics' to study the RNA and protein composition, respectively, of whole samples. (DNA codes for RNA, which provides the template for proteins, which contribute to the functional capacity of an organism, such as the ability to convert atmospheric carbon into particulate matter). The work forms part of a newly proposed Australian Southern Ocean Genome-Based Microbial Observatory (ASOMO).

'Over the next five years the ASOMO program plans to compare whole water samples of archaea and bacteria collected in the same locations in different seasons, to understand the genomic and functional differences that occur in the populations,' Dr Cavicchioli says.

'This will provide information on the diversity, energy generating processes and adaptive capabilities of the microbes, and enable predictions to be made about the impact of continued global warming.'



Water samples collected in the Southern Ocean were passed through three filters (stainless steel racks pictured) of decreasing pore size – 3, 0.8 and 0.1 µm – to separate phytoplankton, zooplankton, microbes and viruses. The outflow from the 0.1 µm filter was collected and further concentrated in the 'tangential flow filter' at the front. The 0.1-0.8 µm fractions, which contain the majority of archaea and bacteria, will be sequenced.

Rick Cavicchioli and Torsten Thomas, both from the UNSW, process microbial samples collected at Ace Lake.

Metagenomics will also be used to examine the potential effects of increases in oceanic carbon dioxide (ocean acidification) on microbial communities.

The findings will contribute to a database of information collected for the Census of Antarctic Marine Life – a major Australian-led project of the International Polar Year – of which CEAMARC is a part.

The work also complements the team's research in the lakes of Antarctica's Vestfold Hills, near Davis. These saline lakes were isolated from the ocean about 5000 years ago, providing scientists with an opportunity to define the biological properties required for survival at the extreme limits of life. In 2006, the research team took samples from Ace, Deep and Organic lakes. Metagenomic analysis is expected to provide an understanding of the ecology, adaptive biology and the undiscovered properties of psychrophilic microbes in the lakes.

If the metagenomics approach proves successful, Dr Cavicchioli says it will open up opportunities for a range of other investigations including:

- comparing microbial communities in geographically isolated regions of Antarctica, to understand the degree of diversity within similar but separate areas;
- studying microbes that cannot be cultured in the laboratory; and
- studying microbial communities that contribute to the successful cleanup of contaminated sites.

This article is based on a paper by Dr Cavicchioli that appeared in Microbiology Australia, *September 2007, pp 98-103.*

Broadcasting marine science to the world

Margot Foster is executive producer of ABC Radio National's Bush Telegraph program. She spent six weeks with marine scientists on board the *Aurora Australis* as part of the International Polar Year 'Pole to Pole' project, which also involves Radio New Zealand, BBC and Radio Deutsche Welle. Margot posted an online illustrated diary and set up radio interviews with scientists, recorded from the ship via satellite phone.

ESMEE VAN WIJK

Margot was educated in ocean chemistry and its effects on marine life and weather, among other things, during her participation in the Climate of Antarctica and the Southern Ocean project. Her experiences provided the insights she needed to tell her stories.

When I ascended the gangway I knew only that there were two key research projects being undertaken – the Collaborative East Antarctic Marine Census and Climate of Antarctica and the Southern Ocean. On board I came to meet the 75 others who, in their various roles, ensured that invaluable data was gathered for both these and associated projects.

As the voyage progressed I had a growing sense that I was on board a kind of modern *Beagle* – we were documenting sea life in a part of the world not yet fully explored, we were looking upon habitat never seen before, and we were discovering creatures yet to be named.

I used the fact that I was a science novice to my advantage. To tell stories in a way that ordinary people (like me) could understand I treated the process like baking a cake – step by step, in logical order. I operated in the same way I do working as a radio producer – trusting that what interested me would likely be of interest to others.

My daily diary was the repository of stories that resonated with me and became the springboard for recordings. I roamed the ship with my recorder and camera, trying to be where things happened, asking questions and having processes patiently explained.

I was surrounded by those who enriched the experience by readily answering every question I threw out – 'Why do penguins have that comical waddle? How deep is 'deep'? Why are creatures a more intense red the deeper they dwell? Why is that iceberg black?'

The greatest revelation was seeing science in action up close. I was swept along by the infectious enthusiasm of the scientists. The wet-lab after each trawl was always crowded with onlookers – checking to see what was brought up from the deep. No one was denied a look, explanations were offered, curiosities pointed out, and hypotheses raised and debated.

I wondered how unique it was to have this kind of collaboration. I was observing a holistic application of science with the geologist, biologist, oceanographer and electronic engineer all working together. I watched the close communication, the sharing of information and assistance and, as the rapport grew between chemists, modelers, ecologists, taxonomists, technical support and crew, I thought how much poorer the outcomes would be for each project without the cross-pollination of ideas and knowledge.

The major legacy of the International Geophysical Year 50 years ago was the building of an infrastructure of stations on the Antarctic continent for the pursuit of science. In the International Polar Year, a significant part of the legacy will be the collaborations across disciplines, resulting from cooperative ways of working.

The best science on the voyage was that connected by multiple strands. Similarly, the best stories are those that connect with people's hearts and minds. For me, explaining science is like building up a mosaic. There must be repetition; a telling of the story in many ways. The tiny pieces help make sense of the larger ones, which is why my stories included not only interviews with project leaders, but also the French fisherman who spent the trip mending the trawl nets, and pieces on the remarkable deck spa fashioned out of a fish tub and why two New Year's Eve celebrations were held on board.

It's that mix of stories that conveys something of what it is to work intensively on a dedicated marine research vessel in a remote and unpredictable environment. The better the work is understood, the greater the support for it, which is why the stories from the voyage must be shared and why the important work must continue.

MARGOT FOSTER
ABC Radio National

More information:

Read Margot's diary: www.caml.aq/voyages/aurora-australis-200708/index.html

Download interviews on Radio National: www.abc.net.au/rn/scienceshow/

ALEXIA MADDOX

VENOM EVOLUTION

Venomous animals, in all their glorious shapes and sizes, have been the abiding passion of my life. Venom systems are key evolutionary innovations that have arisen independently in a myriad of animal groups.

The most extensively studied venoms are from the medically-important snakes, yet venom systems are also present in a diverse range of other animals including lizards (Gila Monster, Komodo Dragon), mammals (platypus, shrews), fish (stingrays, stonefish), molluscs (octopus, cone snails), cnidarians (blue-bottle, box jellyfish) and echinoderms (Crown of Thorns starfish, flower urchin). Venom systems have also evolved independently within several arthropod groups such as centipedes, scorpions, spiders, stabbing insects and stinging insects.

I am working on a general theory of how venom evolves by applying all the theories I developed on reptile venom evolution, to other orders. I am currently concentrating on the molecular evolution of venom proteins in cephalopods (cuttlefish, nautiluses, octopuses and squids) from tropical and temperate waters. As with snakes and lizards, there are many more venomous cephalopod species than appreciated.

During the recent Collaborative East Antarctic Marine Census I was astounded at the biodiversity of the Antarctic waters. The tropics are always portrayed in documentaries as marine hotspots. They are, of course, much more accessible and amenable for research than Antarctic waters. But the sheer quantity and diversity of life in the Southern Ocean rivals anything I have seen on my expeditions to the Great Barrier Reef, Coral Sea, Asia, the Carribean, or other locations in between. Two venomous lineages – octopuses and anemones – were very well represented, both in total numbers and species diversity.

After our successful expedition we now have a long, hard slog in the laboratory ahead of us. The first step is to DNA bar code (genetically fingerprint) each octopus to reveal the biodiversity present in the Antarctic waters. We have already completed this aspect and are currently analysing the results.

The second step will be to obtain a snapshot of every protein being produced at the time the venom glands were removed. I have already achieved this with octopuses, cuttlefish, centipedes, fish, snakes and even the venom glands of the iconic Komodo Dragon. My studies of octopus and cuttlefish venom glands show that they have toxic proteins in common, resulting from early 'recruitment' events into the chemical arsenal of their common ancestor. However, during the subsequent evolution of the animals themselves, they have recruited new proteins

Bryan collects a reef cuttlefish (Sepia latimanus) *in the Coral Sea.*

into the chemical arsenal that are unique to each lineage. This shows that while cephalopods share a common venomous ancestor, the venom system continues to diversify.

The third step in the process will identify the range of proteins in the venom and their relative quantities. The glands of each specimen will be analysed separately to reveal their unique molecular fingerprints, thus revealing any regional variation within and between species.

These results will guide bioactivity testing to determine the effects of the crude venom and purified individual toxins on living cells. The activity of the crude venom is greater than the sum of the individual components, due to the synergistic action that often occurs between different molecules.

Of particular interest will be the gene sequences and actions of enzymes from cold water cephalopod species (from Antarctica and Norway), with the same types of enzymes from temperate and tropical species. Temperature is a major variable in the action of enzymes and most enzymes have a narrow 'sweet spot' of optimal activity. As the same enzyme classes are shared between tropical and Antarctic species, significant biochemical changes must exist between them in order for activity to occur at the radically different temperatures (32°C versus –2°C). The fundamental changes responsible for the activity at different temperatures will be elucidated by comparing differences in the sequence of amino acids (protein building blocks) and then making chimeric versions of the proteins in the laboratory to determine which amino acids confer the temperature-dependent activities.

In our studies of temperate and tropical species so far, we have discovered new small proteins with very intriguing activities, which are potentially useful in drug design and development. We will be searching for new small proteins in the venoms of the specimens we have collected on this expedition.

The trip to Antarctica was not only a professional bonanza but also as close to a religious experience as I will ever get. I hope one day to return to the mecca of the frozen South.

**In addition to the award of berths by the Australian Antarctic Division, this research is funded by the Australian Research Council, Australian Academy of Sciences (J.G. Russell Award), the CASS Foundation and the Australian & Pacific Science Foundation.*

BRYAN GRIEG FRY
Group Leader, Venomics Research Laboratory, Bio21 Institute, University of Melbourne

Bryan with an olive sea snake (Aipysurus laevis).

DAVID WACHENFELD

This octopus, Megaleledone setebos, *collected for venom research during CEAMARC, is endemic to Antarctica.*

ROBIN BEAMAN

After completing a PhD on the biochemistry of snake venoms at the University of Queensland's Drug Design and Development Centre, Dr Bryan Fry undertook a two year postdoc at the National University of Singapore. He then joined the Australian Venom Research Unit as Deputy Director (Research) for four years. He now leads his own venom research group within the University of Melbourne's Department of Biochemistry and Molecular Biology. Bryan spends a great deal of time traveling the world to collect and milk venomous snakes and other animals. His work has lead to the discovery that the number of venomous snakes in the world is around 2700, not 250, as was originally accepted. He has

AAD

also found that the evolution of reptile venom goes back much further than previously thought – approximately 200 million years– and that the toxic effects caused by the bites of the Komodo Dragon are caused by venom, not by toxic bacteria.

SUPPORTING SCIENTISTS AT SEA

The creativity and skill of a small group of specialist technicians have provided scientists with the first insights into the Antarctic sea ice environment in early spring and an unprecedented glimpse at life on the bottom of the Southern Ocean.

During two International Polar Year marine science voyages – the Sea Ice Physics and Ecosystem eXperiment (SIPEX) and the Collaborative East Antarctic Marine Census (CEAMARC) – in September 2007 and March 2008, respectively, the Australian Antarctic Division's Marine Science Support team designed, manufactured and maintained much of the unique data-gathering equipment deployed from the *Aurora Australis*.

Marine Science Support (MSS) is a small section within the Science Technical Support unit of the Antarctic Division, which consists of engineers, gear officers, computer programmers and electronic technicians. On each voyage the team works from 20-foot containers, which act as storerooms and workshops, and take all kinds of electrical and mechanical parts and supplies.

ACE CRC

SIPEX scientists prepare to deploy a high definition video camera and lamp system to study krill distribution and behaviour under the sea ice. The camera, developed by Marine Science Support, could be lowered through a hole in the ice or attached to the Surface and Under Ice Trawl net. The same camera was used on the beam trawl during CEAMARC, in a more robust aluminium housing for deep sea work.

'Whilst we know what spares and consumables we need to run and maintain Antarctic Division equipment, we have to anticipate what may be required for other organisations' equipment,' marine engineer, Tony Veness, says.

'Equipment is often designed at short notice with little time for testing in the real-life situation and there are a lot of "first offs" on many voyages, so we need to accommodate on-the-fly modifications and improvements.'

A video camera mounted on a beam trawl for CEAMARC, for example, was a first for the *Aurora Australis*. Prior to the voyage the MSS team took a standard video camera and fabricated watertight housings that could withstand the extreme pressure of working at depths of up to 2000 m. The team worked closely with the Antarctic Division's instrument workshop to design the housings and, after models had been made and tested, the final product was machined, anodised and pressure tested – in one month. Modifications were then made as required during the voyage.

'We were making changes to the camera and lamp angles, focal length and the embedded software of the system controller throughout the voyage, to improve the stability and clarity of images,' Tony says.

Equipment designed for the SIPEX voyage had its own peculiar requirements. As the scientists were interested in the sea ice and the ocean at shallow depths in early spring, the gear had to function in very cold air temperatures.

'We needed equipment that could be manipulated and operated by someone wearing gloves and we also had to try to keep equipment warm, or at least warm it up before it was deployed to gather data,' Tony says.

MSS staff on the SIPEX voyage were responsible for operating and maintaining equipment at sampling stations; from jiffy drills, ice corers and generators, to a Remotely Operated Vehicle that was lowered through a hole drilled in the sea ice, to map the distribution of microscopic ice algae that live in and on the underside of the ice.

They also deployed a range of trawl nets between ice stations, including the Surface and Under Ice Trawl (SUIT) and other plankton nets. During SIPEX the SUIT was used to collect krill from under the sea ice, to aid research into the ice-associated food web (see story page 17).

Tony says there are plenty of challenges supporting science programs in the Southern Ocean. The weather and conditions are usually demanding but there are other, often unexpected, challenges.

'For example, a scientist from another country might turn up a few days before a voyage departs with equipment that we've never seen before,' he says.

Twelve-hour shifts are the norm while a cruise is underway, and work can go on for six or more weeks continuously. There is little rest even when the team returns. Much of the six months between shipping seasons is taken up with the servicing, calibration, design, construction, purchase and installation of equipment to be used on the *Aurora Australis* or on small boats. Many projects take a long time to complete, with a great deal of liaison, planning and discussion undertaken before any work is started.

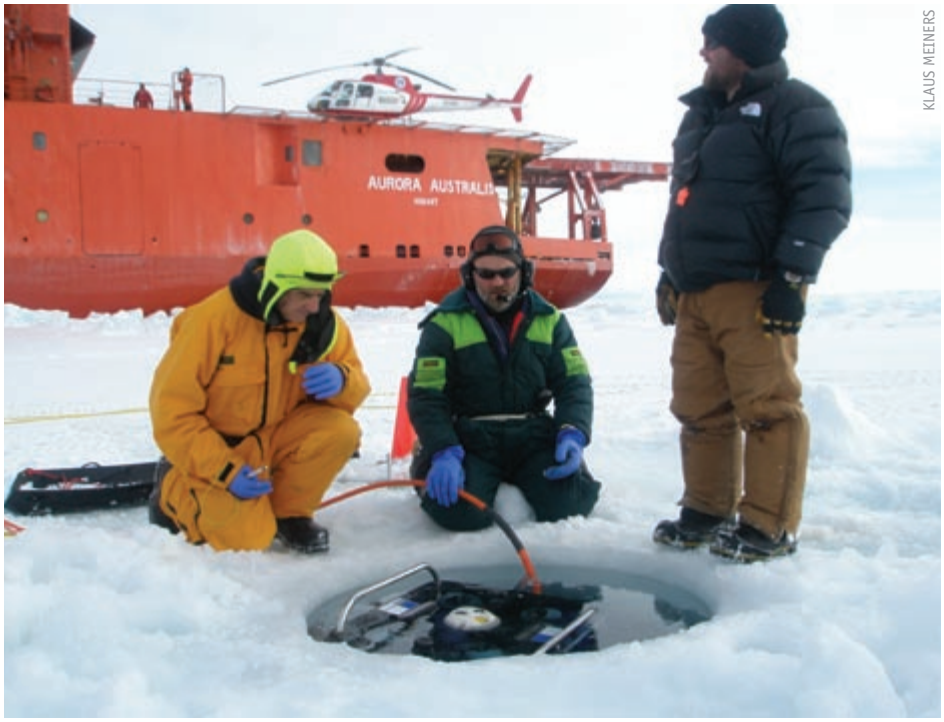
'The *Aurora* was designed and built as a resupply and research vessel and does not have all the capabilities of a full-time research vessel. It takes a lot of work and sometimes some creativity to rearrange the deck equipment and set things up to support the specific needs of a unique scientific voyage,' Tony says.

The team also liaises with P&O Polar and contractors regarding the design and installation of new instruments, refurbishment of laboratories and writing new software to suit particular voyage needs.

Tony says the work of the MSS requires people with a unique combination of skills and availability. He says it's often quite difficult to find staff, but the work does attract students, recent graduates and recently retired people keen to apply their skills in a different arena.

'The skills needed to work in science support roles are quite different to those required in industry. Finding someone with the technical skill is not such an issue, but they need to be able to consult and communicate effectively with scientists, be willing to work long hours for many weeks at sea, and have a genuine interest in scientific discovery.'

JILL BUTTERWORTH
Information Services, AAD



KLAUS MEINERS

Marine Science Support members Alan Poole (left), Peter Raymond and Andrew Cawthorne, deploy an instrumented Remotely Operated Vehicle through a drill-hole beside the ship during SIPEX.

TONY VENESS

Marine Science Support gear officer, Stuart Crapper, with the French beam trawl during CEAMARC.

AAD

A sea spider captured by the trawl-mounted video camera during CEAMARC.

Deep sea hits the headlines

The deep sea video footage collected during the CEAMARC voyage was of immense scientific interest, but it also captured the imagination of the general public. Underwater footage and news of giant sea spiders, coralline organisms and deep sea fish were featured in print, television, radio and the internet for months after the voyage returned.

Dr Martin Riddle appeared on ABC TV and radio news in all states and the voyage was reported on SKY News, ABC America, CNN, BBC, National Geographic and a number of other international networks. Dr Riddle was interviewed by Earth and Sky, a science media company whose interviews are heard more than 8 million times each day around the world on more than 1000 radio stations, including Voice of America and Sirius satellite networks.

Shortly after the footage was released, the search term 'giant sea spiders' shot to the top of Yahoo's search engine ranking index and was hailed 'an international internet sensation'.

TONY WORBY

The ship encountered difficult ice conditions during the voyage, including this ridged, 'fish-scale' or 'dragon-scale' ice. This type of ice forms under very cold conditions. The pancakes form when wave action constantly breaks apart the newly forming ice. Sudden extreme pressure (such as from a nearby iceberg or fast ice) and strong winds, cause the pancakes to pile up.

SEA ICE PHYSICS AND ECOSYSTEM EXPERIMENT

The Sea Ice Physics and Ecosystem eXperiment (SIPEX) was Australia's first major field program contributing to the goals of the International Polar Year (IPY). The experiment was conducted from the icebreaker *Aurora Australis* in September and October 2007 and involved 45 scientists from 12 countries.

The multi-disciplinary experiment focused not only on the physics and biology of the sea ice, but the strong interactions and dependencies of the structure, thickness and snow properties and their effects on the under-ice algae and ecosystem of the Southern Ocean.

SIPEX was timed to coincide with the period of maximum sea ice extent. We had an ambitious objective – to penetrate hundreds of kilometres of sea ice until we reached the coast of Antarctica. The ice conditions we encountered were particularly difficult at times, with some incredibly thick ice making it very hard to get the ship where we wanted to go. But with some excellent navigation from the Captain and officers we achieved our objective, arriving at the Antarctic coast approximately 10 days after first reaching the ice edge. We then steamed west past the coastal fast ice and the Dalton Iceberg Tongue, and pushed our way north again through the sea ice until we reached the ice edge again.

While in the sea ice we stopped at 15 'ice stations', where we took a series of measurements to characterise the sea ice environment. Each ice station took between 12-24 hours, with up to 50 scientists working out on the ice floes at once. Each group would haul their sledges of scientific equipment down the gang plank from the ship's hold and onto the ice, identify a suitable region for their experiments and set to work. The work ranged from oceanographic measurements of the temperature, salinity and currents under the ice, to detailed electromagnetic measurements of the conductivity of the ice.

At every ice station a key set of measurements were made along a 200 metre-long transect, and were coordinated to provide detailed surface measurements of the ice and snow properties of the ice floe. We would lay out a long tape measure (fastened down by tent pegs in windy conditions) along which measurements of snow thickness and density were made. This was followed by measurements using a sled-mounted snow radar, to identify the snow layers which most affect the reflection of a radar signal. This information was used to estimate snow thickness.

Once all the snow measurements were completed a group of hardy souls, known as the drilling team, would measure the ice thickness at one metre intervals. This is a fairly easy task when the ice is relatively thin and level, but when the ice is ridged it can be over five metres thick and drilling through it can be a problem – even with an electric power drill and auger. The thickness data provide a detailed profile of the variability in ice thickness across the floe, which together with information from ice cores, tells us how

the ice floe formed. The ice cores were usually taken at three places along each transect and then analysed in a freezer laboratory on the ship to reveal the crystal structure of the ice, its salinity and other chemical parameters.

These surface measurements were used to validate other instruments, such as the laser altimeter (see page 16) and snow radar, which were mounted on a helicopter. The helicopter-based measurements provide information over much larger areas (hundreds of kilometres), but the information collected along the thickness transects helps to validate, or 'anchor' the aircraft measurements with real surface measurements. At each ice station the helicopter would fly over the transect so that the airborne and surface measurements could be compared. The aircraft measurements in turn helped to validate satellite-based measurements, which provide data over the entire Antarctic sea ice zone. This information can then be used to detect larger-scale changes.

A great deal of data was collected during SIPEX that will not only improve our understanding of the physics and biology of the Antarctic sea ice zone, but also provide a baseline against which any future changes can be assessed.

ANTHONY WORBY
SIPEX Voyage Leader, ACE CRC and AAD

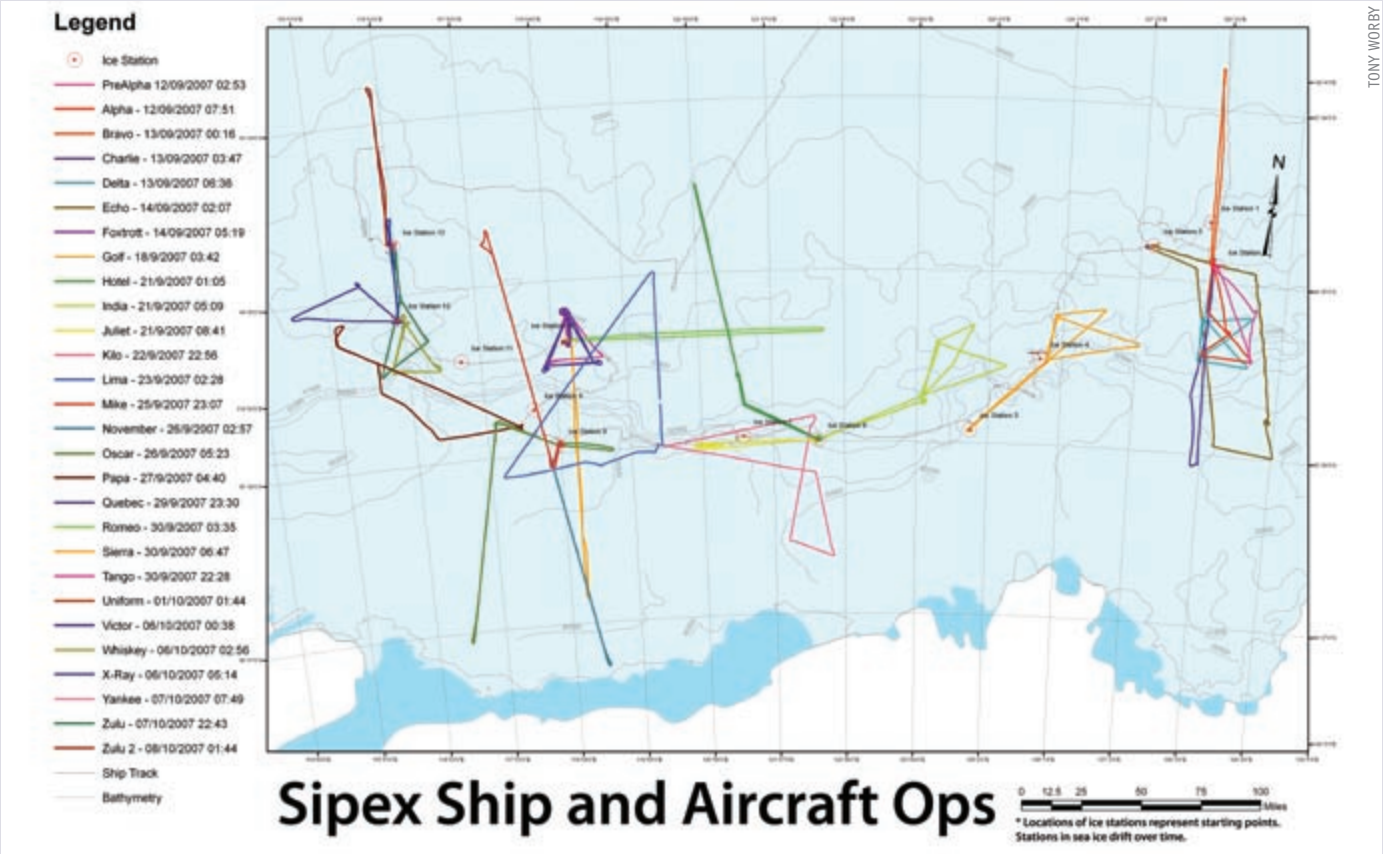
More information: www.acecrc.sipex.aq

TONY WORBY

A 200 m transect is established at Ice Station 6. Note the sled-mounted snow radar towards the top right of the image.

TONY WORBY

The SIPEX team.



TONY WORBY

Location of ship and helicopter operations during SIPEX. Surface measurements of ice and snow properties were made at each ice station and were used to validate helicopter-based measurements, which in turn validated satellite measurements. Altogether these measurements provide data over the entire Antarctic sea ice zone, which can be used to detect large-scale changes in sea ice.

DETERMINING SEA ICE THICK
WITH AN AIRBORNE SCANNI

Sea ice is regarded by many as the 'canary in the coal mine' for climate researchers. Model climate predictions show that an expected increase in air temperature will be most dramatic in the polar regions and that summer Arctic sea ice extent will decline further in the next 10 to 20 years.

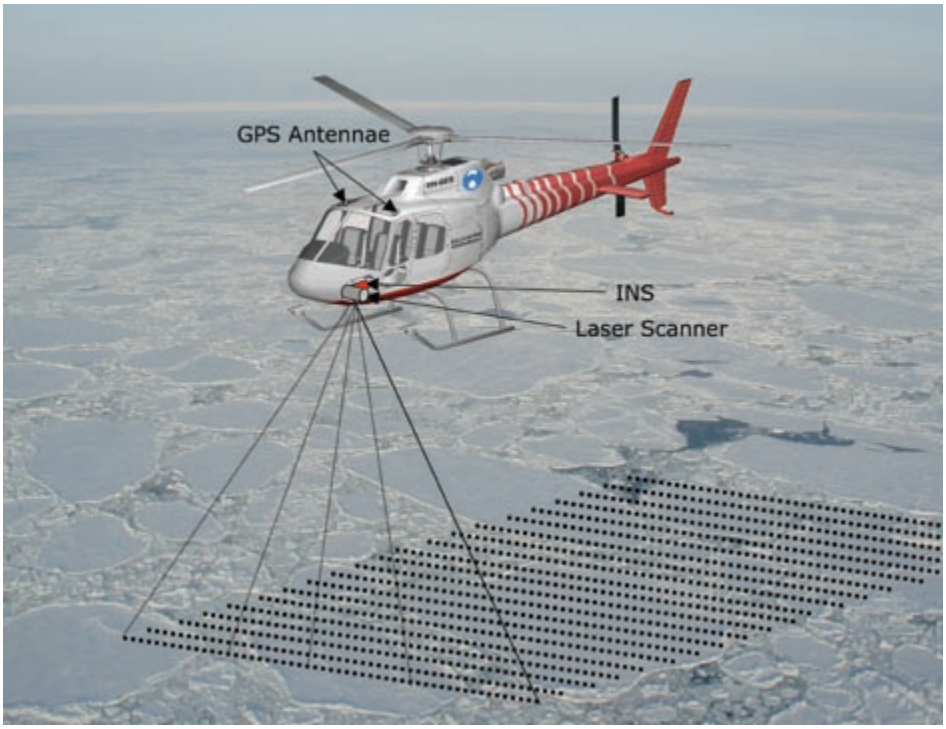


Figure 1: The laser scanning principle.

While Antarctic sea ice extent and concentration is routinely monitored from space, it is currently unknown whether changes are occurring in its thickness distribution, and therefore its mass balance, in response to environmental change.

To address this issue we used recent advances in technology to take a close look at sea ice off the coast of East Antarctica during the Sea Ice Physics and Ecosystem eXperiment (SIPEX). A range of different instruments were mounted in a Eurocopter AS 350 'Squirrel' helicopter for long-distance (up to 250 nautical miles) aerial surveys of sea ice. These included: 1. a scanning laser system (a recent acquisition of the Australian Antarctic Division) in combination with radar, to determine sea ice and snow cover properties (ultimately thickness); 2. a digital camera to take aerial photographs for sea ice classification and concentration estimates; and 3. a pyrometer for measuring surface temperature. The latter helps to identify sea ice type, particularly for thin (new) ice. An inertial navigation system (INS) also provided precise information on the helicopter's location and attitude during operation. All together the aircraft was named 'RAPPLS', which stands for Radar-Aerial Photography-Pyrometer-Laser Scanner.

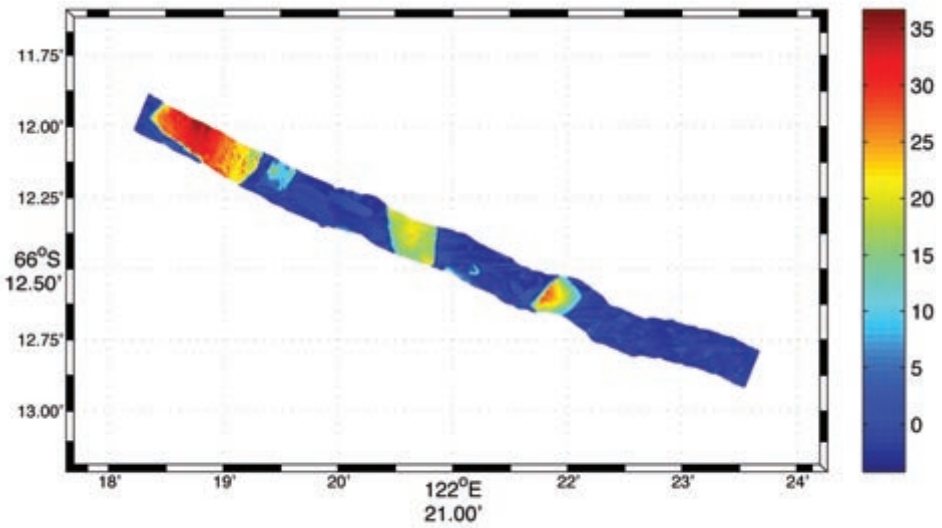


Figure 2: Sample of an approximately 2 km flight track of laser scanner-derived surface elevation [m] over the Dalton Iceberg Tongue showing some bigger icebergs enclosed by sea ice.

The centimetre-precision scanning laser was used for the first time during SIPEX in the East Antarctic sea ice zone to determine the surface roughness and elevation of the sea ice. These estimates of sea ice freeboard (the part of the ice that projects above the water) can then be converted into total thickness if certain physical properties of the ice are known, such as ice density and snow cover thickness and density. Important information on the latter is derived from the airborne radar system. The *in situ* measurements were made at 14 ice stations. Every time the *Aurora Australis* was anchored in the pack ice and helicopter operations commenced, scientists measured

NESS
NG LASER

sea ice thickness by drilling holes along a 200 m transect. Sea ice cores were also taken for analysis of ice structure and density, while snow properties were measured during snow pit sampling. After flying over these 200 m transects the airborne data were calibrated for the long range surveys.

The laser scanner produces an across-track scanning pattern of the underlying surface (Figure 1). This pattern can be adapted to different applications, flying altitudes and speed. During SIPEX, we used a setup which allowed us to scan with a swath width of about 450 m. We successfully used the laser system on 28 flights for over 50 hours. The data are currently being processed at the Antarctic Climate and Ecosystems Cooperative Research Centre (ACE CRC) in close cooperation with the Australian Antarctic Division.

Figure 2 shows an example of 1 million surface elevation points (about 3000 scanner lines out of 4.5 million lines collected in total, over about a 2 km flight track) over a section of the Dalton Iceberg Tongue at 66.21°S, 122.35°E. A prominent feature in the north-west corner of the image is a sea ice enclosed iceberg with an edge height of about 30 m and two smaller icebergs further down to the south-east. Some distinctive floes can be seen within the sea ice matrix and even wind-blown features like snow dunes can be identified in the data.

This example demonstrates the great potential for sea ice monitoring and validation of space-borne sea ice thickness estimates (such as those from NASA's ICESat – a laser altimeter satellite – or ESA's upcoming CryoSat-II – a dedicated cryosphere radar mission). It also demonstrates the capabilities of high precision range measurements for digital elevation mapping of glaciers, ice shelves, icebergs, and islands. In combination with the simultaneously taken digital aerial photographs, we will produce high resolution 3-D digital elevation models. This work represents the first in a series of airborne sea ice monitoring efforts to be carried out by the Australian Antarctic Division, and will make an important contribution to improving our understanding of the thickness of East Antarctic sea ice and its spatio-temporal variability.

JAN L. LIESER
ACE CRC

A krill larva at the final larval stage – Fucilia VI stage – just before moulting to become a juvenile krill.

SO KAWAGUCHI

Sea ice algae put spring in krill growth

Researchers have found that spring-time growth of sea ice algae is critical to krill growth and reproductive potential.

The annual formation and retreat of sea ice around Antarctica is one of the largest physical changes on Earth. Besides its substantial impact on both regional and global climate, the ice cover plays a pivotal role in the biogeochemical cycles of the Southern Ocean and is an important structural element of Antarctic marine ecosystems. Forming a centimetre- to metre-thick skin on the ocean's surface, sea ice provides a platform for marine birds and mammals and a substrate for microalgae. It is also a habitat for Antarctic krill – a key species in the Southern Ocean food chain – that feed on ice algae during winter and spring, when food in the water column is scarce.

The importance of sea ice for marine ecological and biogeochemical processes is still poorly understood and information on the physical, chemical and biological properties of sea ice during winter and early spring is scarce. Classical ice sampling methods – often based on ice corers with small diameters – provide insufficient data to understand large-scale processes. New methods and technologies are needed to answer two important and pressing questions: how does the winter sea-ice extent affect biological productivity off East Antarctica and; how sensitive are krill populations to potential future changes in sea ice extent?

During the Sea Ice Physics and Ecosystem eXperiment (SIPEX) we used newly developed sampling and observing systems and technologies to address these questions. These included an instrumented Remotely Operated Vehicle (ROV) equipped with a sonar, light sensors and camera system, to observe and film krill under sea ice, and a custom-built Surface and Under Ice Trawl (SUIT) and Rectangular Midwater Trawl to collect animals for physiological experiments.

The ROV was piloted from a control stand within a laboratory container on board the *Aurora Australis*, while a small crew operated its 350 m-long tether at a drill-hole out on the ice floe. Using online sonar data, the ROV could be 'flown' at a known distance to the subsurface of the ice, and while video observations were performed, measurements of the under-ice light field were taken. These optical measurements are used to estimate the algal biomass within the sea ice. The method allows the quantification of ice algal biomass along transects and is approximately 20 times faster than classical ice coring methods, saving valuable ship time.

cont...

Scientists deploy the Remotely Operated Vehicle.

The SUIT – customised by the Australian Antarctic Division's Marine Science Technical Support team (see story page 12) – floats directly under the ice and catches krill that are feeding at the subsurface of the ice floes. The deployment of this truck-sized trawl requires the coordination of ship officers on the bridge, winch operators, and gear officers and crew on the trawl deck. After demanding trials both in open water and thin ice, the trawl was successfully used in the inner pack, allowing us to catch krill from directly under the ice. Captured krill were then assessed for their feeding conditions. Experiments on krill growth rates and their demographic measurements were also conducted.

We found that adult krill were just about to start boosting their maturity in preparation for summer reproduction, by utilising ice algae under ice floes as a food source, as well as phytoplankton blooms in areas where the ice had started to retreat. During the voyage krill larvae were also found to be on the verge of accelerating their growth rates, in preparation for summer.

Undoubtedly, the amount and timing of algae associated with sea ice, and in open water at retreating ice edges, are very important determinants for krill population dynamics. Preliminary analysis of the data suggests that SIPEX was carried out at the very moment when biological activities were taking off in our survey area off East Antarctica. New methods were successfully deployed and tested and will allow time- and cost-effective sampling and monitoring of the sea ice habitat in the future.

The collected information on the physical, chemical and biological parameters of sea ice, in combination with our work on krill, will allow us to relate the performance of krill with various sea ice conditions and habitats during spring, and to help forecast what might happen to krill populations given possible future changes in sea ice extent.

KLAUS MEINERS[1] and SO KAWAGUCHI[2]
1 Antarctic Marine Ecosystems program, ACE CRC
2 Southern Ocean Ecosystems program, AAD

The Surface and Under Ice Trawl, being deployed from the Aurora Australis, *is equipped with a high-resolution video system to film the subsurface of the sea ice.*

Scientists sample thin sea ice from a cage attached to the ship's crane.

TODAY'S YOUTH – TOMORROW'S ANTARCTIC SCIENTISTS

The ranks of future polar scientists could swell considerably after the efforts of teachers and other educators during the International Polar Year.

Take Tasmanian teachers, Jane Dobson and Caroline Lapworth, for example. The pair participated in the Sea Ice Physics and Ecosystem eXperiment (SIPEX) late last year, as part of the project's 'education and outreach' ambitions to communicate and engage a wider audience in the research.

Through their daily blogs, interviews and online education packages, the pair informed students and teachers from schools around the world about the science, the scientists, and daily life on an ice-breaker. Jane and Caroline also had a secret weapon; fluffy off-sider, Polar Knutsen – a small polar bear given to them as a travel buddy by Rosetta Primary School in Hobart. Polar's job was to interview scientists and other expeditioners during the voyage and report his findings to students.

Among other things, the trio provided information to teachers for classroom experiments, such as understanding the science behind frostbite, ocean currents and snow density. They also posted information on a range of questions being investigated during the SIPEX voyage, relating to sea ice physics, sea ice ecology and oceanography, and answered 'Questions of the Day' from school students.

ACE CRC

Jane (left), Polar Knutsen, Caroline, and Dr Rob Massom, measure snow cover properties (density, grain size, stratigraphy, temperature and salinity) on sea ice in a snow pit.

'The educational opportunities that this project has opened up to students, not just in Tasmania, but worldwide, are fantastic,' the pair said on their return from Antarctica.

'This is the first time it has been possible to share information interactively from Antarctica by teachers in Australia, and we feel proud and privileged to be a part of it.'

To read the SIPEX interviews and blogs, or to find educational material relating to the voyage research, visit www.acecrc.sipex.aq

Jane and Caroline's blog: Day 32, 6 October 2007

We decided to hang out with Dr Rob [Massom] today to see what he gets up to out on the ice. Dr Rob is interested in the snow that collects on the ice floe, in particular looking at the different sorts of snow that collect on the ice, and what role the snow plays in controlling heat exchange between the ocean and the atmosphere, and in stopping light from filtering through to the sea.

Dr Rob works on the transect – he digs snow pits and analyses the snow. A snow pit is a hole in the snow with vertical sides that allows Dr Rob to see the different layers of snow that have collected on the ice floe. When you look at it closely there are actually lots of different types of snow. Snow is made of ice crystals, and different shaped crystals (grains) give the snow different characteristics. When snow first falls its grains are angular and pointy and look a bit like the typical snowflake we all think of. Snow that has been hit by the wind has more rounded grains and forms a hard crust on the surface. Snow that has melted and refrozen has larger rounded grains. Older and colder snow has large crystals and forms layers called 'depth hoar', which are very crumbly. Dr Rob looks at the layers in the snow pit and records what sort of snow there is at different depths. He also takes snow density samples throughout the depth of the pit, so he can see how the density of the snow changes with depth. He also uses a conductivity meter to measure the wetness of the snow. Liquid water conducts electricity, as the molecules can move around to carry a current. Frozen water (like snow crystals) on the other hand doesn't conduct electricity as well, because the molecules are in a fixed position and can't move around to carry a current. So the conductivity tester sends a current through the snow – the wetter the snow is the more current will pass through it and visa versa.

We were quite surprised at how clearly we could see different layers within the snow and you can roughly gauge how firm the snow is just by sticking a pencil into the different layers and seeing how easily it goes in. A lot of scientists use really complex equipment that most people wouldn't have a clue about how it works, but scientists do use simple techniques too, in fact the simpler something is the better, especially down here where the cold affects everything!

TRACING ELEMENTS IN THE OCEAN

The surface waters of the vast Southern Ocean are suffering from 'marine anaemia' – a serious deficiency in the micronutrient iron.

Just as iron deficiency negatively affects the health and productivity of humans and other land-based creatures, so it affects the phytoplankton (microscopic marine plants) existing in the oceanic realm.

The environmental consequences of this condition restrict primary production (photosynthesis) in the surface waters of the ocean. This means that less carbon dioxide is taken up from the atmosphere to fuel phytoplankton growth. The smaller the transfer of this greenhouse gas is from air to sea, the greater are the consequences for Earth's climate. It is the sequestering of carbon dioxide in the deeper ocean and deep-sea sediments that provides a natural contribution to solving the problem.

During the International Polar Year (IPY), teams of international scientists on several research ships are investigating iron and other trace element micronutrients (such as zinc, cobalt, aluminium, copper and manganese) in cold, high-latitude waters around both poles. The research aims to understand the distribution and cycling of these important micronutrients, how they are supplied to the ocean, and how they affect the different phytoplankton communities in polar waters of both Hemispheres.

This cooperative program – the IPY-GEOTRACES Bipolar project – is supported by GEOTRACES, a new decade-long global science program focusing on trace elements in the oceans.

Under IPY-GEOTRACES, research voyages are being run along key transects in the Southern Ocean (Figure 1) – the 'choke points' for the Antarctic Circumpolar Current, where land masses impinge on this massive radial circulation. German and Dutch scientists on *Polarstern* recently surveyed

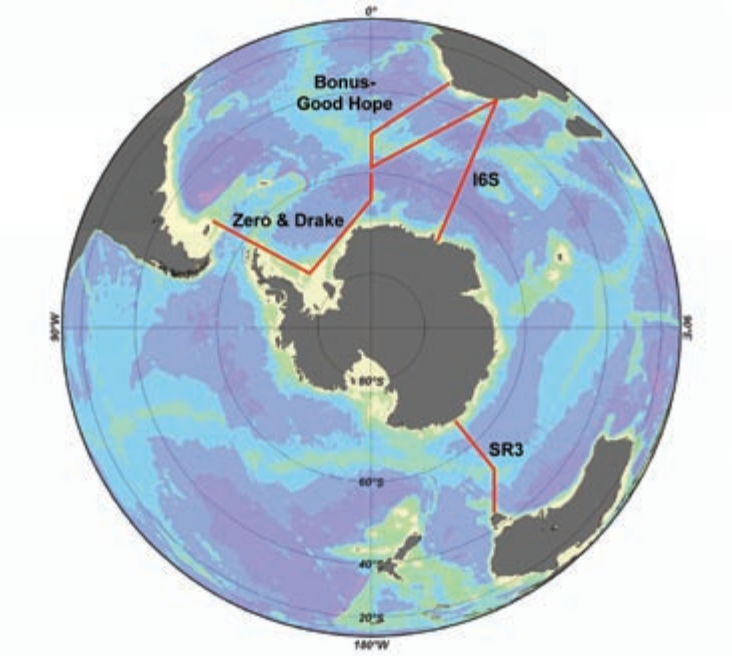


Figure 1. Southern Ocean transects occupied during the International Polar Year-GEOTRACES Bipolar project by Australian (SR3), French (Bonus-Good Hope), German (Zero & Drake) and United States (I6S) research vessels.

along the 'Zero Meridian' (0° longitude), then back northward across the Strait of Magellan, through the Drake Passage and along the South American coast ('Zero & Drake'). French and Belgian scientists on *Marion Dufresne* made a voyage ('Bonus-Good Hope') out of Cape Town, South Africa, which ran diagonally across to the Zero Meridian, then overlapped the track of *Polarstern* to the coast of Antarctica and returned to Durban. Concurrently, US scientists followed a transect line south of Africa ('I6S'), at approximately 30°E.

In March-April this year, an Australian-led voyage aboard *Aurora Australis*, organised by the Antarctic Climate and Ecosystems Cooperative Research Centre, followed the 'SR3' transect along approximately 140°E, between Tasmania and the coast of Antarctica. This transect has been well characterised oceanographically in the past two decades (*Australian Antarctic Magazine* 8: 4). Scientists gathered samples with great care, to prevent contamination from the water column, at each degree of latitude along this north-south transect. Some trace elements (such as iron and mercury) were measured directly using ship-board instrumentation. Others, in their various forms, will be analysed in laboratories later. A high volume aerosol sampler was also deployed to measure the concentration of dust in the atmosphere, since dust blown from continental land masses is likely to be the main source of iron in the remote ocean south of Australia.

The results of this work will yield the first synoptic, circumpolar measurements of micronutrient trace elements in the Southern Ocean. Dissolved iron data along the SR3 transect (Figure 2) represent an order of magnitude improvement in sampling resolution and show widespread iron limitation in upper ocean waters along the transect. These and related observations promise to reveal important information concerning primary production in this region, phytoplankton community structure, and ultimately, a better understanding of the important regulators of climate change. Through this and similar projects, scientists are beginning to learn how the functioning of Southern Ocean ecosystems is constrained by the small 'cogs and gears' of iron and other trace element micronutrients.

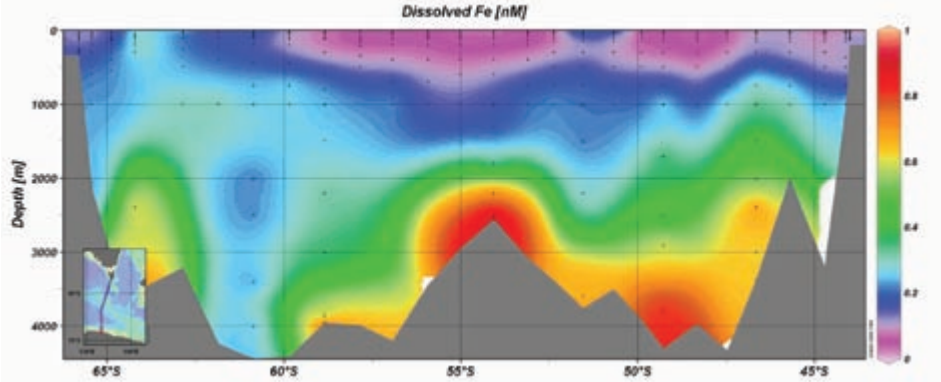


Figure 2. Dissolved iron distributions in the full-water column along the SR3 transect between Tasmania and Antarctica (Bowie et al., unpublished data)

EDWARD BUTLER[1,2] and ANDREW BOWIE[1]

1 ACE CRC
2 Centre for Australian Weather and Climate Research

More information:

IPY GEOTRACES project - www.ipy.org/index.php?ipy/detail/ipy_geotraces/

GEOTRACES project - www.geotraces.org

South with Russia

During the 2007-08 summer Sandra Potter experienced another side of Antarctica – geographically and culturally – on the vessel supporting Russia's national Antarctic research program.


VICTOR POMELOV

Leningradskaya Station.


SANDRA POTTER

The 30-seater MI-8 helicopter.


SANDRA POTTER

RV Akademic Fedorov

Most Antarctic expeditioners return from their voyages brimming with memories of their encounters with ice, wildlife, wild seas and surreal sunsets. My two months aboard the RV *Akademic Fedorov* were memorable more so on account of the different cultural and operational experiences thrown into the equation. These included: finding my place in a community who, for the most part, did not speak much English or who could not navigate through my accent; the same designated seating for every one of our 200-plus meals onboard; a diet with which I sometimes struggled; flights in a helicopter able to carry up to 30 personnel; a six-day diversion to evacuate an expeditioner through McMurdo; a dozen or so clock changes as we sailed through 230° of longitude; visiting the primary school at Chile's Presidente Eduardo Frei station; working with the distraction of the ship-board 'paparazzi' as seemingly constant companions; blessings by the priest who was enroute to Bellingshausen station and its 'Antarctic Holy Trinity Patriarch Cathedral of The Holy Trinity St. Sergius Lavra'; and Australia Day, Women's Day and Military Day celebrations toasted with vodkas and pork fat chasers.

Akademic Fedorov is 141 m long and was built in Finland in 1987. Onboard were 78 crew and 75 expeditioners (the 94 m RSV *Aurora Australis* has a crew of about 21). As part of an International Polar Year research program led by the Australian Antarctic Division's Dr Graham Hosie, (*Australian Antarctic Magazine* 13: 12), I deployed a continuous plankton recorder behind the ship. The 1300 nautical miles of samples obtained from between 64°S 174°W and 64°S 152°W, and 69°S 96°W and 68°S 76°W include samples believed to be the first collected from the Amundsen Sea and Bellinghausen Sea. Previous surveys have mostly been restricted to the region between 60 and 160°E.

No less importantly, my participation also gave me the opportunity to gain a first-hand appreciation of the aspirations and logistical challenges faced by other national Antarctic programs. The voyage was the second leg of the 53rd Russian Antarctic Expedition and made the first visits in 17 years to Leningradskaya and Russkaja stations. Leningradskaya is perched on the edge of a cliff 300 m above sea level on the Oates Land Coast. Russkaja is located in Marie Byrd Land, West Antarctica. At about the time of the stations' last occupation the Russian program's budget had plummeted almost 10-fold.

After the condition of the stations was assessed and new meteorological and geodetic equipment installed, we headed to the Antarctic Peninsula to resupply Bellingshausen, one of eight stations making up 'suburban' King George Island. Our track took us via the coast of Ellsworth Land to enable the 14-member Korean team onboard to undertake reconnaissances of the islands and nunataks of the Canesteo Peninsula and Hudson Mountains region. These flights were made with the view to selecting a site for Korea's second Antarctic station.

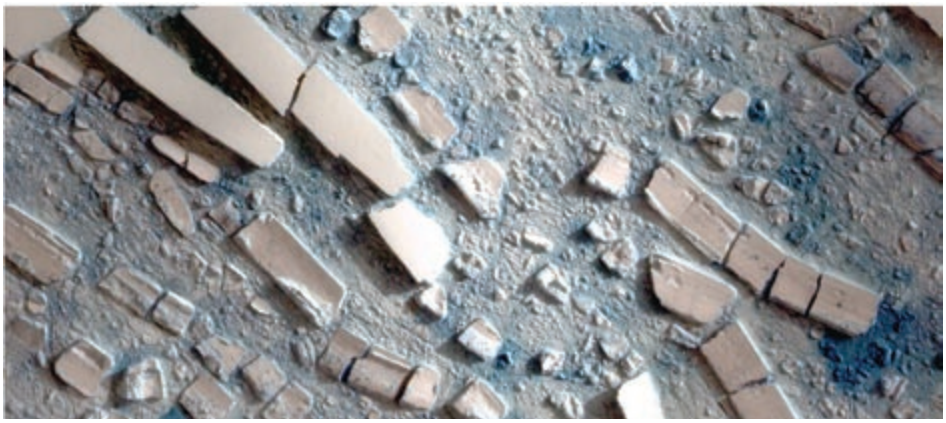
The long periods at sea also provided opportunities for Victor Pomelov, the Russian Antarctic Expedition's Environmental Manager, and I, to exchange ideas on environmental protection matters. We were able to progress the development of quarantine measures for the Larsemann Hills Antarctic Specially Managed Area. The measures proposed have since been endorsed by the other Antarctic Treaty parties active in the region; namely China, India and Romania. The result appears to be Antarctica's first multilateral, regional quarantine arrangement.

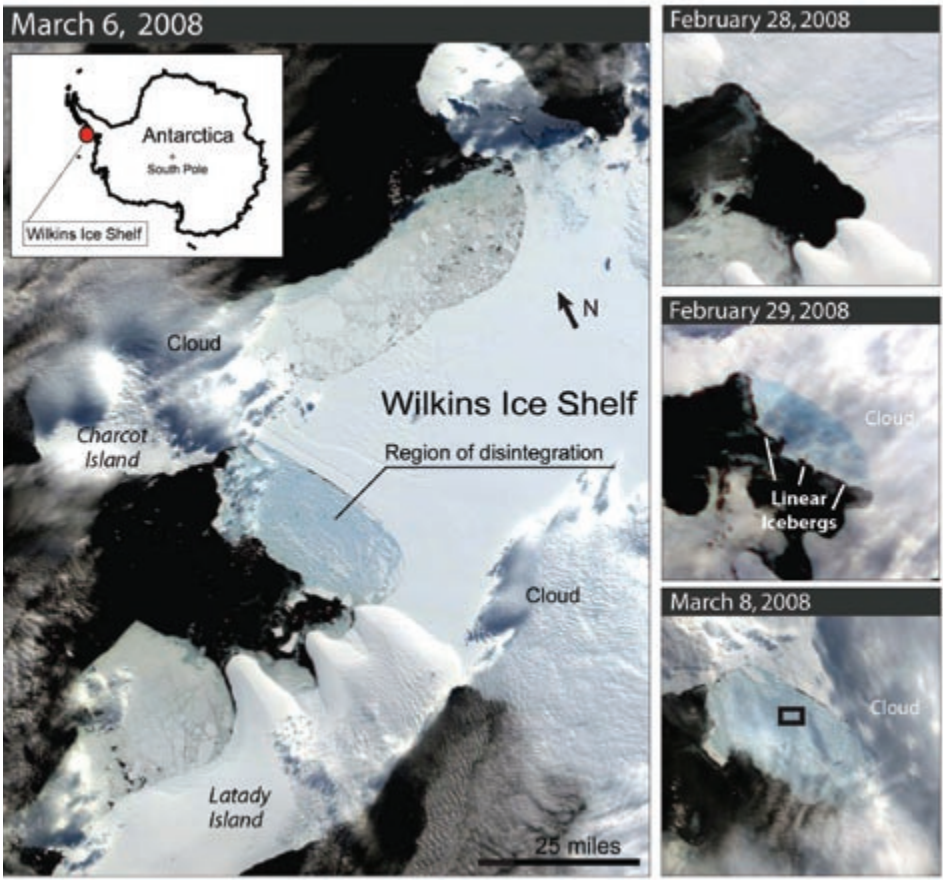
SANDRA POTTER
Senior Environmental Policy Advisor, AAD


VICTOR POMELOV

Sandra Potter's work in the Australian Antarctic Division has spanned logistics, environmental policy and research activities. Prior to working on environment protection issues, Sandra was part of the Division's shipping and air operations team and has led or otherwise participated in 12 marine science and resupply voyages to the Antarctic and sub-Antarctic.

RAPID DISINTEGRATION OF ANOTHER ICE SHELF ON THE ANTARCTIC PENINSULA





Series of four NASA MODIS visible satellite images (spatial resolution 250 m) showing the Wilkins Ice Shelf as it began to break up, from 28 February to 8 March 2008. The ice shelf location is shown in the inset. The upper panel is a high-resolution, enhanced colour image of a region of the ice-shelf break-up on 8 March 2008 (marked on the MODIS image from that date), showing narrow linear icebergs (about 150 m across) crumbling into house-sized ice rubble as a result of the break-up. This image, from Taiwan's Formosat-2, has a ground dimension of 3.2 x 1.8 km.

MODIS images courtesy of the US National Snow and Ice Data Center (NSIDC). Formosat-2 image courtesy of NSIDC/Dr Cheng-Chien Liu, National Cheng Kung University(NCKU), Taiwan, and Taiwan's National Space Organization; processed at Earth Dynamic System Research Center at NCKU, Taiwan.

The ice shelves that skirt the Antarctic continent are broad plates of floating ice, typically 200-300 m thick at their outer margins. Because these are in direct contact with the underlying ocean and atmosphere, they are much more sensitive to climate change than the grounded ice sheet.

Recent events along the Antarctic Peninsula have demonstrated that ice shelves can change very rapidly in a warming world.

In late February 2008, satellite images from NASA's Moderate Resolution Imaging Spectroradiometer (MODIS) onboard the Terra and Aqua satellites, revealed that the Wilkins Ice Shelf had started an abrupt break-up linked to regional warming (see figure). The Wilkins Ice Shelf is situated on the south-western flank of the Antarctic Peninsula (at 70.25°S, 73.0°W), about 1600 km south of South America. This event was the latest in a series of similar extraordinary ice shelf disintegrations that have stunned glaciologists by their speed and size, and have become iconic indicators of rapid change to the world's ice. For example, the size of the Larsen A Ice Shelf (on the eastern flank of the Peninsula) decreased over many years before collapsing completely in about a week at the end of January 1995; and 3250 sq km of the adjoining Larsen B Ice Shelf disintegrated in just five weeks in 2002. The Wilkins Ice Shelf is more than 500 km further south than Larsen B, but lies on the warmer, western side of the Peninsula.

These abrupt collapses are linked to intense summer surface melt in the years prior to break-up, associated with a recorded regional air temperature rise of nearly 3°C over the past

50 years – up to six times greater than the global average. Several models for these break-ups have been proposed, including a hydro-fracturing process whereby an ice shelf, probably thinned and weakened from enhanced melt on its underside, is broken into blocks by the pressure from large volumes of meltwater filling crevasses. Additional factors may come from 'toppling blocks' within the fractured ice shelf and natural weakening by rift formation.

The collapse of the Wilkins Ice Shelf was precipitated by the calving of a long, thin iceberg (41 x 2.5 km in size) from the shelf's southwestern front between 28 and 29 February. This triggered a runaway disintegration of 405 sq km of the shelf behind and led to the calving of thousands of small icebergs over the next few days. The sky-blue pattern of exposed deep glacial ice seen in the figure is characteristic of rapid climate-induced ice shelf disintegrations, and was also seen on the Larsen B Ice Shelf in 2002. As of 23 March 2008, Wilkins Ice Shelf was pinned in place by a narrow beam of ice only six kilometres wide that extended from Charcot Island. When this beam gives way (probably in the summer of 2008-09), a sizeable part of the remaining 13 200 sq km of the Wilkins Ice Sheet will likely rapidly break-up, possibly by the same 'disintegration' process.

This disintegration will not contribute directly to global sea level rise, as the ice released to melt was already afloat. After the Larsen B Ice Shelf collapsed, several of the glaciers feeding into it, no longer constrained by back pressure from the shelf, accelerated significantly, discharging more grounded ice into the ocean and contributing to a slight sea level rise. This is not expected to happen if (when) the Wilkins Ice Shelf collapses completely, as there are no sizeable glaciers feeding it. However, the recent ice shelf break-up events around the Antarctic Peninsula have removed features that appear to have been stable over several centuries to millennia – with major physical and ecological ramifications.

This latest event underlines the complexity of an Antarctic system undergoing rapid change, and highlights the need to more fully understand the processes responsible for such rapid collapse and its impact on the flow of grounded ice behind the ice shelves. With this in mind we are examining the potential role of enhanced wave-ice interaction, due to a reduced sea ice cover, in precipitating the break-up. The Antarctic Peninsula may well be a model for a warmer Antarctica – with future changes occurring at a greater scale and speed, than was previously considered possible.

ROBERT MASSOM[1], IAN ALLISON[1] and TED SCAMBOS[2]

1 AAD and ACE CRC
2 US National Snow and Ice Data Center, Boulder, Colorado, USA

Making Australian aviation history

Australia made aviation history this year with the landing of its first passenger aircraft, the Airbus A319, on Wilkins Runway in Antarctica.

The Wilkins Runway crew unveil a plaque commemorating the opening of the runway.

The successful introduction of the air service to Antarctica is the culmination of several years work and brings to fruition a concept first mooted over 40 years ago.

Federal Environment Minister, Peter Garrett, joined Australian Antarctic Division staff, scientists and invited media on the first passenger flight between Australia and Antarctica on 10th January. Four and a half hours after departing Hobart the aircraft touched down on Wilkins Runway, about 70 km from Casey.

The Minister was greeted on his arrival by the Wilkins Runway Supervisor, Mr Matt Filipowski and Casey Station Leader, Dr Jeremy Smith. Whilst on the ground, the Minister inspected the runway facilities before taking a flight on a C212 around the Casey region.

Two weeks later the Governor General, His Excellency Major General Michael Jeffery, officially opened Wilkins Runway. He spoke to the Wilkins crew via a telephone link from the Antarctic Division headquarters, near Hobart, after his visit to the runway was cancelled due to bad weather.

'It is fitting that that the runway is named after Sir George Hubert Wilkins, one of the great pioneers of polar exploration and aviation,' Major General Jeffery said.

'He encountered many of the same perils that face our Antarctic aviators today – ferocious wind, ice and snow blizzards and absolute isolation.'

He said the ease and speed with which scientists could now reach Antarctica would have major benefits, particularly in the collection of ice cores near Law Dome (providing climate information for the past 90 000 years) and an ambitious international effort to recover a one million year old ice core in the Aurora Basin.

'While this project may take several years and require international collaboration, the scientific results will be enormously significant, and will be expedited through the air link and this runway,' Major General Jeffery said.

The aircraft undertook 10 proving and passenger flights to Antarctica during the summer, including two flights to McMurdo station. Several tonnes of cargo and equipment were also flown to Wilkins during the summer, supporting a range of projects. Up to 15 flights are planned for 2008-09.

For more information and a link to video footage of the A319 landing in Antarctica visit www.aad.gov.au/default.asp?casid=34182

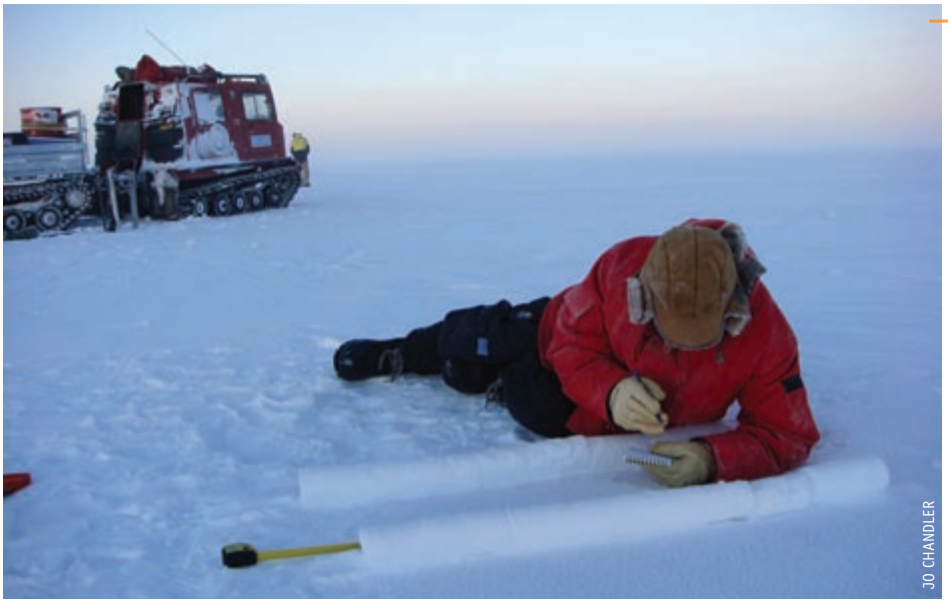
To read the Governor General's full speech on the opening of Wilkins Runway visit www.gg.gov.au/governorgeneral/news.php?action=view&id=198

Information Services, AAD

Federal Environment Minister, Peter Garrett, in Antarctica after the first passenger flight on 10 January 2008.

COSMIC CLUES INTO SOLAR

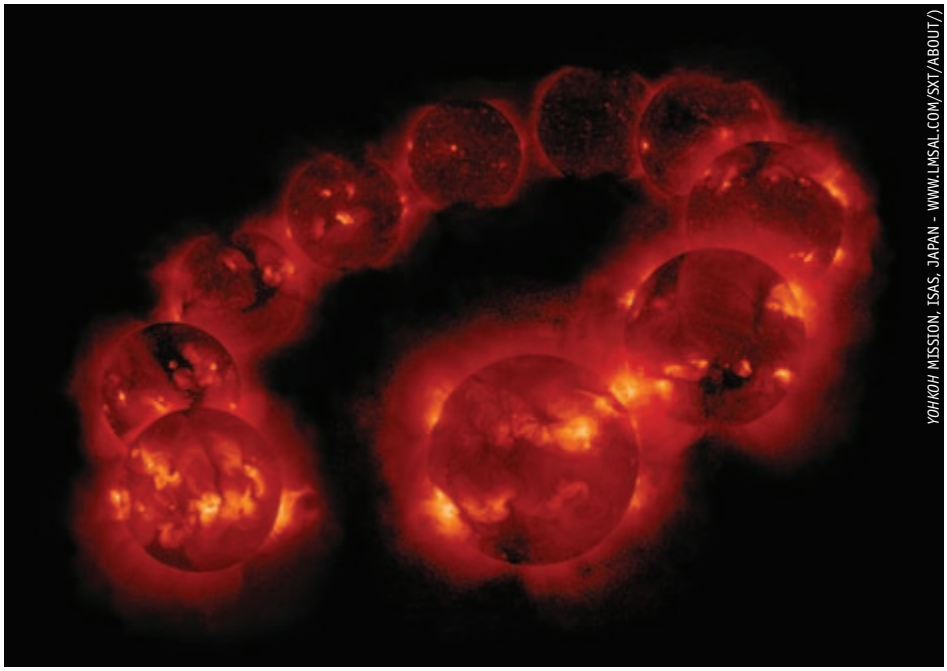
With the introduction of Australia's Antarctic air link, scientists can investigate the link between solar activity and climate using short-lived radioactive isotopes in ice cores.



JO CHANDLER

A cosmic ray, a proton far more energetic than our largest particle accelerators can produce, is created in the remnants of a distant supernova explosion. For thousands of years it travels through space at nearly the speed of light, passing the occasional nebula and galaxy, heading for a spiral arm of the Milky Way. It is on a collision course with our solar system and, as it nears, it penetrates the heliosphere and is deflected by the Sun's magnetic field. But not enough. As it closes in on Earth its path is bent to follow a terrestrial magnetic field line towards the southern geomagnetic pole.

At about 20 km above the Earth's surface, within the stratosphere, the cosmic ray collides with atmospheric atoms, initiating a cascade of atomic and subatomic particles. These energetic secondary particles continue the process, smashing apart nuclei all the way to the Earth's surface and a few metres below it. Eventually the huge energy of the cosmic ray is spent. One of the products of these nuclear reactions is the element beryllium – fragments of oxygen and nitrogen nuclei that were smashed into the smaller beryllium nucleus. The stable beryllium nucleus contains four protons and five neutrons and has an atomic mass of nine (beryllium-9). Beryllium has two radioisotopes of interest; beryllium-10, with an extra neutron and a half life of 1.5 million years, and beryllium-7, with only three neutrons and a half life of just 53 days (decaying to the more stable lithium nucleus).



YOHKOH MISSION, ISAS, JAPAN - WWW.LMSAL.COM/SXT/ABOUT/)

Solar magnetic activity captured in x-ray over the 11-year solar cycle by the Yohkoh Soft X-ray Telescope (ISAS, Japan). Cosmic rays from outside the solar system are deflected by the Sun's magnetic field. Changes in the Sun's activity alter the intensity of cosmic rays arriving at Earth and the production of beryllium radio-isotopes in the atmosphere.

Let us follow the fate of the cosmogenic (cosmic-ray-produced) beryllium-7 nuclei. Its solitary existence in the stratosphere is brief, before a small particle (perhaps a sulphate aerosol from a volcanic eruption years ago) traps it by adsorption to its surface. Now without any significant momentum of its own, it travels as a passenger on the small particle, at the whim of the air mass that carries it.

There is a barrier of stable air that separates the stratosphere from the troposphere beneath it, where weather patterns unfold. A disturbance causes a weakness in this stable layer that allows the particle and its beryllium-7 passenger to move into the troposphere. A pressure difference draws the air mass towards the Antarctic continent. Ice crystals jostle our particle and trap it. More ice mass is accumulated until the ice crystal feels the force of Earth's gravity. It tumbles towards the summit of Law Dome, a small ice cap some 200 km in diameter, on the edge of the main East Antarctic ice sheet, and the site of the Australian Antarctic Division's (AAD) on-going ice core drilling and glaciology projects. Over time it is buried beneath snow layers.

Later, three scientists arrive at Law Dome. They drive a tube into the snow surface and extract an ice core containing the ice crystal and its cosmogenic beryllium-7 passenger. But this is not the only beryllium-7 atom in their ice core; there will be a few thousand others, among some 10^{22} water molecules, in each gram of ice. But the clock has been ticking since the isotope's formation in the atmosphere. All haste must be made to measure the beryllium-7 record before its short half life expires.

ACTIVITY AND CLIMATE

Australian Antarctic Division ice core chemist, Mark Curran, catalogues ice cores for beryllium-7 measurements from the Law Dome ice cap. As beryllium-7 decays quickly the ice samples must be returned rapidly to Australia for measurement, making the air link indispensable for this research.

The scientists take five parallel ice cores and bundle them carefully into the back of a Hägglund, taking them to Casey station, about 100 km away. The new Antarctic air link is now indispensable. Within days of sampling the ice cores are flown to Hobart, where they are cut into sections representing the snowfall events that occurred over the past weeks and months. The ice samples are filtered to remove dust particles and micro-meteorites – other cosmic components that could confuse results. Beryllium-7 atoms from each sample are chemically trapped in small columns, which are flown by express freight to the Australian Nuclear Science and Technology Organisation (ANSTO) laboratories in Sydney. The ice samples with the beryllium-7 are now concentrated into a smaller volume and placed inside a gamma radiation detector for several days. By chance, the beryllium-7 atom that we have followed decays while it is inside the detector, becoming lithium-7 and emitting a gamma ray of characteristic energy. The gamma ray is detected and the (former) presence of our beryllium-7 atom is inferred. The epic journey of our cosmic ray across the universe has not been in vain! The scientists are also interested in the beryllium-10 signal, but this is not so urgent a matter. They have a few million years to make their measurement, but this time in a particle accelerator at ANSTO, using accelerator mass spectrometry.

Scientists are interested in beryllium radioisotopes for a number of reasons. The production rate of radio-beryllium in the atmosphere is governed by the intensity of the Sun's magnetic field, which acts to deflect cosmic rays away from Earth. Furthermore, the Sun's magnetic field is linked to solar activity, including total solar irradiance and the spectral distribution of energy from the Sun. Therefore the production of radio-beryllium in the atmosphere is intimately related to solar activity. Beryllium-10 retrieved from ice cores has become arguably the best indicator of solar activity over the past tens of thousands of years, way beyond the limit of the instrumental record. Of great interest to climate scientists is the possible relationship between changes in solar activity and climate change on Earth. It is widely agreed that solar activity is only a minor contributor to the observed warming of the last century (the period of anthropogenic global warming). However, over longer time scales some researchers have argued that changes in solar activity may have played a leading role in causing climate change on Earth.

The most significant area of uncertainty confronting research into beryllium-10 is a poor understanding of the processes that control its transport from the point of production in the atmosphere to its deposition at polar ice caps. For example, it is misleading to interpret beryllium-10 concentrations directly as 'solar activity' without accounting for the confounding influences of climate processes. To improve our understanding of solar influences on climate in the past, an improved understanding of these processes is sought.

Beryllium-7 is a useful tool to address this problem. Investigating the ratio of beryllium-10 to beryllium-7 provides information on the movement and residence time of beryllium-10 in the atmosphere. The very different decay rates of the two radioisotopes serve as a 'clock' for air mass age, which is particularly useful for studying the transport of gasses from mid-latitudes to the poles, and vertical gas exchange within the atmosphere. For example, high ratios of beryllium-10 to -7 are indicative of 'older' air from higher up in the atmosphere (i.e. the stratosphere) while lower ratios represent 'younger' air (i.e. with tropospheric origins).

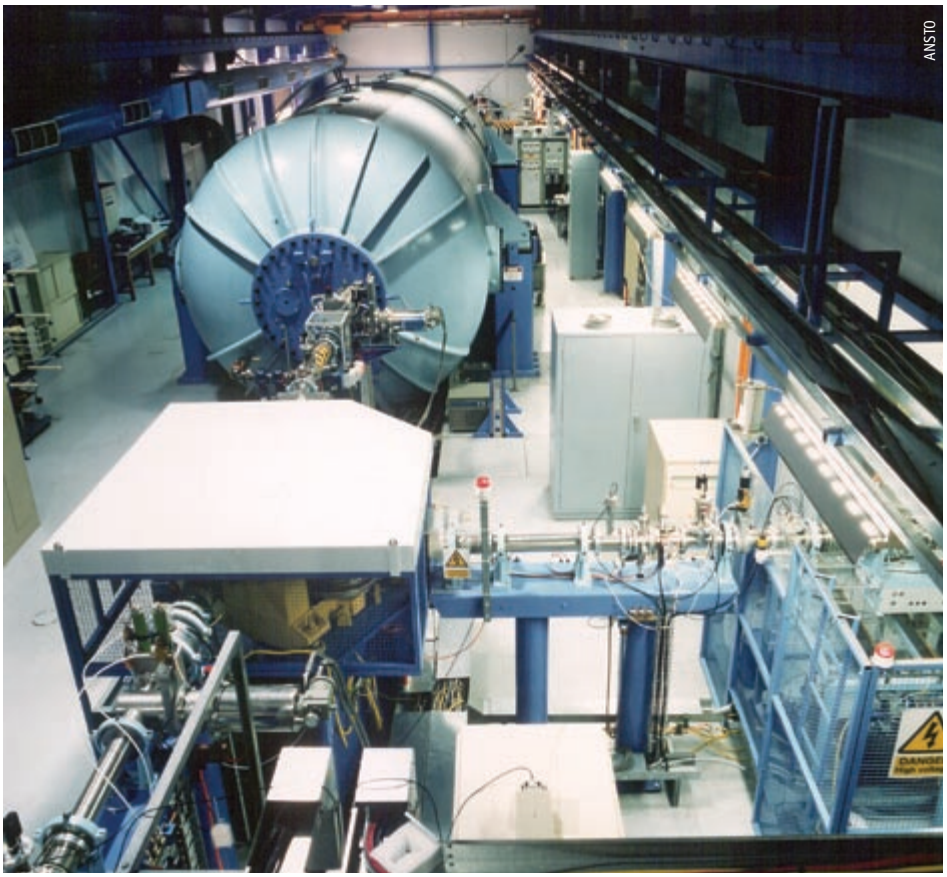
Research into beryllium-7 has been difficult in the past, due to the long and infrequent sea voyages between Antarctica and Australia. The introduction of the air link allows ice cores to be extracted from Antarctica and measured for beryllium-7 within a couple of weeks. A preliminary study involving ANSTO, the AAD and the University of Tasmania, was carried out during the 2007-08 glaciology field campaign at Law Dome, using the air link to rapidly return samples from Law Dome summit to Australia. Processing of the data from this record is in progress and will be used to inform the strategy for a more targeted campaign to sample beryllium-7 at Law Dome in 2008-09.

JOEL PEDRO[1] and ANDREW SMITH[2]

1 IASOS, University of Tasmania
2 Institute for Environmental Research, ANSTO

More information:

http://neo.ansto.gov.au/environment/projects/ccash



The 10 million volt particle accelerator – the Australian National Tandem Accelerator for Applied Research – at ANSTO is used to measure beryllium-10 signatures in ice cores.

UNDERSTANDING THE TOLERANCE OF ANTARCTIC MOSSES TO CLIMATE CHANGE

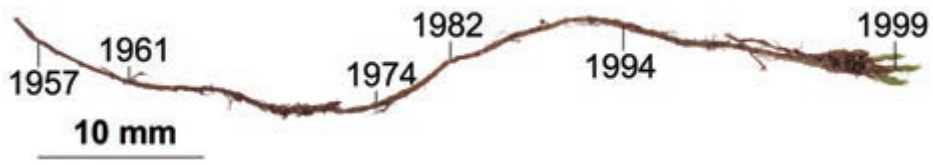
SHARON ROBINSON

A typical moss turf from Antarctic Specially Protected Area 135 near Casey station. The undulations are caused by frost heaving. Most of the moss shown here is the endemic Schistidium antarctici *(olive green in colour), which is the dominant moss species in the area. The bright green mosses at the front of the image are* Bryum pseudotriquetrum *and the red patches on the ridge tops are likely to be* Ceratodon purpureus. S. antarctic *and* C. purpureus *are hard to tell apart in the field and microscopic analysis is usually required to confirm identity.*

Climate change is expected to affect the high latitudes first and most severely, rendering Antarctica one of the most significant baseline environments for the study of global climate change.

Despite this, there have been few long-term studies of the response of Antarctic vegetation to climate change. The Windmill Islands region supports some of the most extensive and best developed vegetation on continental Antarctica, with lush, green mossbeds along many of the lakes and melt streams close to Casey station. Over the past 12 years my University of Wollongong colleagues and I have studied the mosses of this region to better understand how they are responding to climate change.

Our research has provided evidence that the Antarctic endemic moss *Schistidium antarctici* is likely to be more susceptible to climate change than two co-occurring cosmopolitan species *Ceratodon purpureus* and *Bryum pseudotriquetrum*. Initially we focused on how increasing springtime UV-B radiation, caused by the 'Antarctic ozone hole', was affecting these three mosses. We found that *S. antarctici* was more susceptible to UV-B-induced DNA damage than the cosmopolitan moss species. This is probably due to the endemic moss having the lowest concentration of sunscreen compounds of the three mosses. *C. purpureus* is the most UV-tolerant of the three mosses and PhD student, Laurence Clarke, has shown that although *C. purpureus* and *B. pseudotriquetrum* contain similar overall levels of sunscreen compounds, the location of the compounds varies between the two species. *C. purpureus* concentrates the sunscreens in its cell walls, whereas in *B. pseudotriquetrum* they are distributed evenly between the cytoplasm and cell walls. We think that wall-bound sunscreens offer a more spatially uniform and potentially more effective UV screen, which may explain why *C. purpureus* is so tolerant of UV-B radiation.



Radiocarbon isotope analysis has allowed researchers to determine the age and growth rate of moss shoots.

Work by Jane Wasley showed that whilst the endemic species thrives in melt streams and melt lakes, it is less able to cope with drier environments. In contrast, the two cosmopolitan species are much more tolerant of drier conditions. One of the impacts of climate change in this region of Antarctica is a drying trend – evidenced by the increased salinity of terrestrial lakes over past decades. Our results suggest that the two cosmopolitan species may out-compete the endemic one as the climate continues to change.

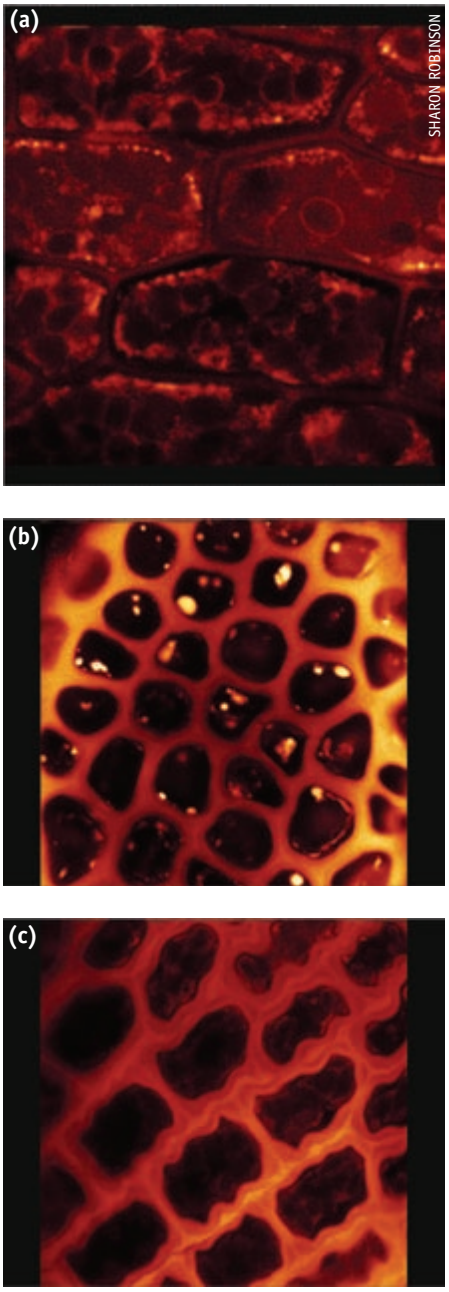
A collaboration with David Fink and Quan Hua at the Australian Nuclear Science and Technology Organisation (ANSTO) has allowed us to determine the age of these moss shoots and determine accurate growth rates using radiocarbon isotope analyses. Our results show that the oldest moss shoot sections predate the 1960s peak in atmospheric 14C due to nuclear testing, indicating average growth rates between 0.4 and 1.6 mm per year. We were also able to detect changes in growth rate over the last 50 years, allowing the influence of environmental variables on growth rates and water relations of Antarctic mosses to be explored over time periods not possible using other techniques.

Our results suggest that high wind speeds and ozone depletion typically have negative impacts on the growth of these mosses, whereas temperature tends to have a positive effect. Stable carbon isotope ($\delta^{13}C$) signatures in the mosses reveal when mosses were exposed to wetter and drier periods in the past, and also suggest that the growth rate of some species is water-limited. Recovery of the ozone layer and warming predicted for the Antarctic are likely to increase growth rates, whereas the already observed increase in wind speeds may negatively impact the growth of Antarctic mosses. These studies of past growth rates are consistent with results from other studies, which indicate moss communities are retracting into the wetter microhabitats.

Whilst short-term manipulative experiments are important in enabling us to predict the likely impacts of climate change, actual community change can only be determined by rigorous, long-term monitoring. To address this we have established a long-term monitoring program at Casey. We will determine how environmental change affects the terrestrial vegetation of the Windmill Islands by measuring how biodiversity is changing along a set of permanent vegetation transects established in 2002-03. This project has the potential to validate our hypotheses by measuring actual community change.

In the 2007-08 season we collected samples and photographed the quadrats from these transects at Robinson's Ridge (10 km from Casey) and in Antarctic Specially Protected Area 135, near the station. The samples and photographs are currently being analysed and will be compared to those collected in the 2002-03 season to see if our predictions for moss survival are sound.

SHARON ROBINSON and LAURENCE CLARKE
University of Wollongong



Confocal images of leaves from (a) Bryum pseudotriquetrum, *(b)* Ceratodon purpureus *and (c)* Schistidium antarctici *stained with Naturstoffreagenz A to show the localisation of UV-screening compounds in each species. Orange fluorescence indicates the presence of phenolic compounds.*

Genetic adaptation to climate change

Previous studies of Antarctic moss populations have reported extraordinarily high levels of genetic variation, possibly as a result of UV-induced mutation. We used microsatellite DNA markers to compare the genetic variation present in continental Antarctic, sub-Antarctic and temperate populations of the moss *Ceratodon purpureus*. In contrast to previous studies, we found continental Antarctic *C. purpureus* displays less intra-population genetic diversity and lower levels of inter-population gene flow compared to populations from a range of temperate and sub-Antarctic sites. Our data provide no evidence of elevated mutation rates in the Antarctic, and imply climate change will present ongoing challenges for continental Antarctic moss populations with less potential than temperate populations to adapt to environmental change.

ON GUARD AGAINST AN ALIEN INVASION

Aliens in Antarctica!
It sounds like a science fiction thriller. But in fact, Aliens in Antarctica is the first major investigation into the effect of human activities in Antarctica on the invasion potential of alien (non-native) species.

The International Polar Year project is examining the type and amount of 'propagules' (seed, spores and eggs) that are unintentionally imported into the region on clothes, shoes or hand luggage, as well as how many propagules are likely to be deposited and whether they will germinate and grow.

Co-Chair of the project, Dr Dana Bergstrom of the Australian Antarctic Division, says the impact of alien species could range from a minor, transient introduction, to a substantial loss of local biodiversity and changes to ecosystem processes and evolution.

Building on an Australian pilot study conducted a few years ago by Dr Jennie Whinam, Nicki Chilcott and Dr Bergstrom – which found an array of propagules like grass and other seeds, moss spores, plant fragments and soil particles that could potentially hitch-hike to Antarctica on travellers' belongings – an international team of scientists from nine nations has assembled to investigate the size of the problem across the Antarctic region, with over 20 Antarctic nations participating.

This recent Antarctic season saw passengers from over 40 ships and planes participate in a survey of where they had travelled to in the last 12 months. The outdoor clothing and belongings of some expeditioners and tourists were also sampled with special vacuum cleaners, to find any propagules. These data will be analysed over coming months, providing the first snapshot of the threat of alien species introduction posed by humans entering Antarctica.

The Australian team examined over 2000 items of fresh fruit and vegetables destined for Australian Antarctic stations. Eighty-nine per cent of these items were clean, while most of the remaining 11% were being spoilt by blue moulds (*Penicillium sp*). Cargo destined for Antarctic stations was also examined over the same period, with some interesting discoveries.

'We found live springtails and mites in packaging material that was on its way to Antarctica. The material was scheduled to be fumigated, but it demonstrates how important it is to be vigilant in these situations,' Dr Bergstrom says.


MAT OAKES

As part of the Aliens in Antarctica *project an experiment was set up to determine the likelihood of propagules, attached to clothing, being deposited in Antarctica. Here* ABC Catalyst *presenter Paul Willis has his boots laced with seeds by Dana Bergstrom, before walking through a patch of sand to simulate tourist activities in Antarctica.*


DANA BERGSTROM

Although most fresh fruit and vegetables destined for Australian Antarctic stations were free of propagules, a few were found to be rotting, such as these pears and onions.

'Discoveries like this give us an insight into the pathways by which existing alien species might have been introduced into the Antarctic region. There are springtail colonies on some of the sub-Antarctic islands and records of *Penicillium* in soils at Casey that may have been introduced through a similar pathway, before our quarantine procedures were so well established.'

The project team is complementing this real-world work with laboratory-based simulations. In one, seed has been sown on different mediums such as sand, peat and gravel, and at different temperatures, to see what may germinate and grow in the dry, cold Antarctic conditions.

Another simulation involved a team of volunteers play-acting as tourists, using clothing and equipment that had been impregnated with seeds, to test the likelihood of propagules being deposited during a typical tourist visit to a region.

With rapid climate change occurring in some parts of Antarctica, greater numbers of alien introductions and more successful invasions by aliens are likely, with consequent increases in impacts on ecosystems.

The Aliens in Antarctica project provides the first opportunity to assess the absolute size of the threat of alien propagule transfer to the Antarctic region through human activity.

'Once the threat is established, we can formulate appropriate methods to combat the risk,' Dr Bergstrom says.

'Data and information gathered during this project will be reported to the Antarctic Treaty Nations and used to improve conservation and protection practises in the Antarctic region and other sensitive areas around the world.'

JILL BUTTERWORTH
Information Services, AAD

More information:
www.aliensinantarctica.aq

First Antarctic ground-satellite view of ice aerosol clouds at the edge of space

A special atmospheric research campaign for the International Polar Year was undertaken at Davis this summer to gain improved understanding of ice-aerosol layers in Earth's atmosphere and the effects of global climate change.

JOHN FRENCH

Recent observations at Davis reveal that in the Southern Hemisphere noctilucent clouds (pictured) are dimmer and occur less frequently and one kilometer higher than they do in the Northern Hemisphere.

Five scientists and an engineer spent the summer at Davis operating the complex radar and lidar instruments, while the recently launched AIM satellite (Aeronomy of Ice in the Mesosphere) passed overhead. The Davis observations provide the first Southern Hemisphere study of noctilucent clouds using the AIM satellite.

Noctilucent clouds are a rare phenomenon that occur in the polar regions in summer. The clouds form at the edge of space near a height of approximately 85 km in the atmospheric region known as the mesosphere (50-95 km above ground), and exist only when temperatures are below approximately -120°C. In the Southern Hemisphere, the clouds normally occur between late November and early February at latitudes greater than approximately 60°S.

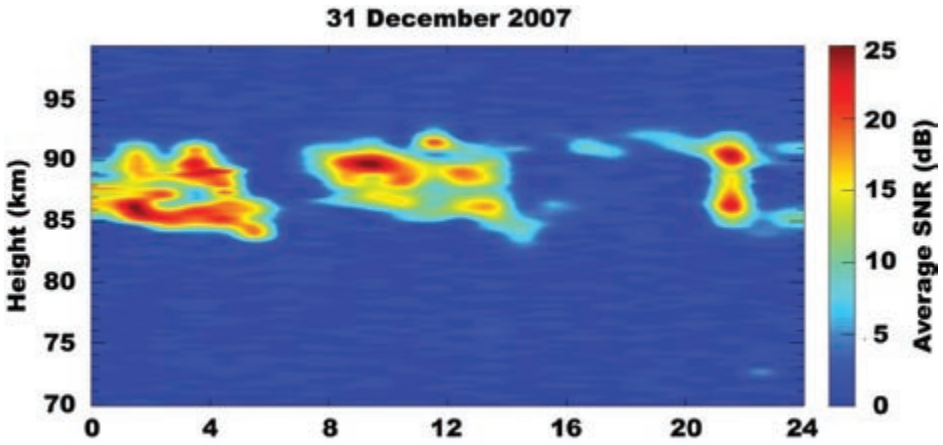
Because of the special conditions required for noctilucent clouds to form, they are regarded as a sensitive indicator of climate in the middle atmosphere. Enhanced greenhouse emissions are leading to a warming at Earth's surface. These gases are also partly responsible for a general cooling of the Earth's stratosphere (10-50 km above). Climate models also predict a cooling of the mesosphere, which will likely lead to greater occurrence and coverage by noctilucent clouds. There is some evidence from the Northern Hemisphere that the clouds are becoming more widespread and brighter.

Noctilucent or 'night shining' clouds are only visually observable when the sun is between six and 16 degrees below the horizon. These special viewing conditions are difficult to obtain from land in the Southern Hemisphere. However, remote sensing instruments such as the radars and the lidar at Davis can detect the icy layers over the full summer season.

The ground-based radar and lidar measurements at Davis will be combined with observations from NASA's AIM satellite to understand the conditions required for the clouds to form. This will help in verifying detailed climate models for the upper atmosphere.

The lidar detects ice-aerosols (noctilucent clouds) with radii larger than 20 nm (1 nm = 10^{-9} m) and the radar detects charged ice-aerosols (or polar mesosphere summer echoes) with radii larger than 3 nm. AIM also detects ice-aerosols with radii larger than 3 nm. Thus, a comparison of our lidar/radar combination at Davis, with AIM, will allow us to distinguish between the ice-aerosols (noctilucent clouds) and charged ice-aerosols (polar mesosphere summer echoes) for the first time in the Southern Hemisphere.

Recent noctilucent cloud (lidar) and polar mesosphere summer echoes (radar) observations from Davis were compared with their Northern Hemisphere counterparts to reveal that in the south they are dimmer and occur less frequently and one kilometre higher. AIM's first Southern Hemisphere observations will provide a space validation of these earlier results, and establish whether the temperatures or water vapour content in this little studied region of the atmosphere are different above the north and south polar regions.



RAY MORRIS AND DANNY RATCLIFFE

Polar Mesosphere Summer Echoes (charged ice aerosols) detected by radar over Davis on New Year's Eve 2007 (SNR = signal-to-noise ratio; dB = decibels).

ANDREW KLEKOCIUK, RAY MORRIS
and JOHN FRENCH
Ice, Ocean, Atmosphere and Climate Program, AAD

More information:
AIM satellite – http://aim.hamptonu.edu/

IGLOO SATELLITE CABINS:

Igloo Satellite Cabins were first manufactured for the Australian Antarctic Division in 1982 by local fibreglasser, the late Malcolm Wallhead. Nick-named 'apples', the brightly coloured domes have been a warm and welcome feature of Antarctic field life for 25 years.

Now manufactured under licence by Penguin Composites Pty Ltd in Penguin, Tasmania, igloos are finding new homes in unusual locations.

While living in England in the 1970s, Malcolm Wallhead designed an igloo-shaped, fibreglass hut ideal for setting up in remote places, far from the pressures of city life. Without sufficient finance for a prototype at that time, the design was stored away until October 1982, when the Australian Antarctic Division's Field Equipment Officer, Rod Ledingham, rang Malcolm for a quote for modifications to a fibreglass caravan-shaped unit. Rod required this unit to be flown suspended under a helicopter, to summer research sites in Antarctica. Malcolm persuaded Rod that a dome shape was more aerodynamic and offered to make one of his igloos instead. He had only a few weeks to make it before the *Nella Dan* departed for Antarctica.

ANTHEA WALLHEAD

Malcolm Wallhead in 1982, with the door of Igloo 001.

Malcolm immediately began working on the original or 'plug' for an eighth of a dome (a single wall panel). Made of plywood coated with fibreglass, the plug was sanded until smooth and then waxed. When completed, fibreglass was laid up on this plug to make a mould, so that eight casts could be produced: three plain panels, four window panels and one door panel. Plugs, moulds and casts were also made for a door, a top escape hatch and two floor panels; completing the prototype. Igloo Satellite Cabin number 001 was first used for penguin research on Magnetic Island near Davis station, and is still in use today as an uninsulated storage hut.

Some modifications were made to the design of the second Igloo. Rod's advice was vital to this development and later units had double-glazed polycarbonate windows instead of single panes, while the floor consisted of four adjoining panels for easier carriage and the door fitted flush with the door panel. Malcolm designed bronze door furniture and aluminium tie-down lugs and later, extension panels – plain and with escape hatches – and a range of furniture, depending on requests from purchasers.

Interiors can be adapted to suit specific requirements and Igloos have been used as mess huts, bedrooms, laboratories, non-magnetic instrument rooms, communication centres and bathrooms, as well as being interconnected with tunnels. Sprayfoam insulation has now been replaced by polyurethane sheet insulation between layers of fibreglass, which makes the Igloos slightly heavier, but still able to be flown by helicopter at 70 knots. While red is the most popular colour for visibility in snow, green, blue, orange, white, beige, yellow and black have also been used.

The Australian Antarctic Division ordered 49 Igloos over the years and in 1986 the first exported Igloo was sent to Svalbard, north of Norway, for the Scott Polar Research

AAD

Igloo 001 in Antarctica.

25 YEARS IN ANTARCTICA

The Max Planck Institute for Ornithology uses their Igloo for bird observations on New Island in the Falkland Islands.

Institute. The website, www.icewall.com.au, also brings enquiries from all over the world, including Alaska, Chile, Cocos (Keeling) Islands, Switzerland, USA, New Zealand and Antarctica.

Igloos have been used in the Papua New Guinea highlands for the Electricity Commission, New Island in the Falklands for bird observations, Greenpeace in Antarctica for their World Park promotion, Falls Creek Ski-lifts for children's education, Google Zurich for meeting rooms in their new offices, and two white extended Igloos, originally purchased by the Australian Navy's Hydrographic Survey, were recently set up in Far North Queensland as accommodation units and called Mawson's Hut and Shackleton's Hut.

2007 marked the 25th year since the first fibreglass Igloo Satellite Cabin was designed and manufactured in Tasmania. As at January 2008, 159 Igloos had been purchased by 45 institutes and individuals in 18 countries, with the majority for use in Antarctica.

ANTHEA WALLHEAD
General Manager, Icewall One

These extended 'tropicalised' Igloos, with tinted windows, window shade hoods and extended roof sections were originally used by the navy for hydrographic surveys on atolls off Far North Queensland. They are now in use at a Queensland resort.

ANTARCTIC DREAMING

'I had dreamed of Antarctica a thousand times before ever I trod upon its frozen shore. But none of my imagining had prepared me for that exhilarating feeling of walking up the gangway onto the *Aurora Australis* at the wharf in Hobart. When I stepped onto the metal deck of the large orange ship, I was grinning like an idiot. This was it. I was *really*, really going to Antarctica.'


Craig at Casey.
CRAIG BUGDEN

That's the first paragraph of the book on travelling to Antarctica that I completed on my recent Arts Fellowship. It was originally going to be a feature article, comparing our voyage with Douglas Mawson's, but like Michelangelo working on the Sistine Chapel ceiling, the original concept just grew and grew and there was always something more to add. Always another great story to put in. Always a new spectacle to describe. In the end I had completed an 85 000 word non-fiction book before we had returned to Hobart.

I went to Antarctica with what I thought was a slightly too ambitious program of things to do (*Australian Antarctic Magazine* 13: 34) – but in fact I found inspiration coming as thick and as fast as a blizzard, and I rolled up my sleeves and wrote like a demon. Whenever I was away from my keyboard I was talking to expeditioners and scientists or going out in the field and visiting places that were quite beyond whatever dreams I had had.

As a result I completed the slightly too ambitious program and more, which included writing a feature article for the media, producing a school's resource on biodiscovery and biosecurity in Antarctica, and running writing workshops with expeditioners as well as undertaking one-on-one sessions with many of them, editing their work to improve it for publication.

I can't recall a period when I've been so inspired to work at such a pace – but in a sense travelling to Antarctica has been in my head for many years. So when it came to writing about it I found that it was bursting to come out and just needed that catalytic inspiration of experiencing the frozen continent first hand (albeit within thick gloves).

Also, in a sense, I have travelled to Antarctica many times through the books of previous expeditioners and explorers. I hope to add to that tradition through my own book, which also seeks to capture many of the stories of the people I met, the voices of the people who do the hard work to make things a success, but who don't get mentioned in most official histories.

And I had so many experiences of my own to write about, whether seeing my first iceberg, climbing mountains up on the Antarctic plateau, flying in a helicopter over the Vestfold Hills, photographing penguins, seeing a spectacular aurora australis (the atmospheric one, not the ship), smelling elephant seals, exploring the different stations, or discovering the mysteries of 'crap and wrap' field toilets.

I feel extraordinarily privileged, not just to have really, *really* travelled to Antarctica, but to have met the people who make Australia's presence in Antarctica a reality. In my opinion, the heroic age of Antarctica isn't over – they are all heroes in their own way, through their enduring spirit of dedication, discovery, adventure, comradeship and love of both acronyms and the great white continent.

Goodness knows what I might have managed to knock off if we'd been stuck in the ice and I had a few weeks more! Well there *is* this novel about Captain Scott that I'm thinking about...

CRAIG CORMICK
Australian Antarctic Arts Fellow 2008


CRAIG CORMICK

Inspiration strikes on a visit to the Shirley Island Adelie penguin colony near Casey.

Nick paints on the beach near Brookes Hut in the Vestfold Hills.

VONNA KELLER

Drawing in Antarctica

Antarctica is a visual overload for an artist – photographs, documentaries and books fail to adequately prepare you for the place. It's bigger, bluer, brighter, harsher and more intriguing than I had imagined, and many of the memories I have are of landscapes I never contemplated seeing.

These experiences of Antarctica will form the foundation for a body of artwork made in my Melbourne studio for an exhibition in late 2008. As well as the practical making of paintings and drawings, I wanted to give an insight into the artistic process and my reactions to the continent. To do this I photographed a selection of my drawings and published them on a purpose-built website during the course of my journey. The website was followed by schools, educators, artists and a global online audience and will be complemented with classroom presentations and discussions.

Over many years I have developed a process of working which involves first building up a large body of drawings from direct observation. I was very fortunate to spend a significant time in the field, at all three Australian Antarctic stations, which allowed me to engage with the landscape and elements first-hand.

Near Casey, I made many drawings of the abandoned Wilkes station, finding it a fascinating combination of landscape and man-made structures. I found myself interested in the slow absorption of the old station buildings back into the landscape, the relentless attack of the weather on the wood, the bitumen and steel of its construction, and bright colours reduced to subdued tones.

The days spent getting to Mawson station and then travelling around in the surrounding mountain ranges was a truly inspiring experience. The sense of anticipation gained on the journey was wholly matched by the drama of the place. From the edge of the fast ice many miles out at sea, mountains floated above the plateau. Details emerged as the ship made slow progress through the ice until the faces of the peaks, crevasse fields and flow lines in the ice, became visible. Finally, from a field hut perched on the side of Mount Henderson, I stood and looked down over the vast expanse of white and out into the berg-scattered ocean. It was an extraordinary opportunity to journey into a landscape this way: glimpsed from far off, emerging gradually and then being immersed in the detail of the terrain. It afforded me a much greater understanding of the processes involved in the formation of the Antarctic landscape.

VONNA KELLER

Nick journeys into the landscape at Wilkes.

I travelled south with few preconceived ideas of what drawings I would make whilst there and what shape the work would take once I got back to my studio. My challenge now is to try and capture some of the Antarctica I have experienced in my work: huge vistas, ribbons of landscape, shattered peaks, the imperceptible drift of vast sheets of ice, and hidden landscapes, such as the rock and mountains under ice and the mass of icebergs beneath the water that we never see.

NICHOLAS HUTCHESON
Australian Antarctic Arts Fellow 2008

To view Nicholas's drawings and paintings visit www.nicholashutcheson.com/antarctic/

Lynette revels in the Antarctic experience that will help fuel the creation of her biography of Syd Kirkby.

CRAIG CORMICK

There's something about Antarctica

Syd Kirkby is a legend of modern Australian Antarctica and I am his biographer. This happy fact 'got me a guernsey' (to use his expression) on the voyage of lifetime, thanks to the Arts Fellowship program of the Australian Antarctic Division.

Syd Kirkby was an ANARE (Australian National Antarctic Research Expeditions) surveyor. He spent three wintering seasons at Mawson in 1956-57, 1960-61 and 1980-81 and was a member of ANARE summer operations from 1961 to 1965 and 1979-80. From his most eastern astrofix to his most western astrofix is 3000 miles. There are no 400 mile spans in the Australian Antarctic Territory (AAT) in which Syd did not have a first landing and a first astrofix. In 1962-63 Syd went to Oates Land, on the eastern extremity of the AAT, and neighbouring George V Land. 1964-65 saw him exploring and mapping Enderby and Kemp lands on the AAT's most western extremity.

On my voyage south, a community of multi-skilled hands gathered each day to hear lectures on a range of topics, typically covering the areas of research that had brought the presenter to Antarctica. Before we reached Mawson I had the first draft of the first chapter written so I offered a paper in the lecture series – in fact, by voyage end I'd offered two and had to be restrained from fronting up again.

It is wonderful for a historian to present historical narratives to non-historians. My outline of Syd's achievements was greeted with awe. Equally enriching for me was the astonishment of my fellow expeditioners when I told them that I had completed all the interviews with Syd and other significant ANARE expeditioners, as well as newspaper, parliamentary, archival and secondary research, but that I still needed to see and experience the place before I could write a word.

Historians capture events through time, but we also locate that moving stream of history in its geographical place. We need, in short, to experience the place where the events happened. Visiting Mount Henderson, having a guided tour around old Mawson station, seeing where the dogs were tethered, walking on the blue ice of the plateau behind Mawson, experiencing the lack of horizon and perspective afforded by a white-on-white landscape, being 'blizzed in' in a tiny hut as the katabatics shuddered its single skin timber walls into a jittery xylophone of movement; these things set the stage to create the biography.

Our wonderful guide, Vonna Keller, took us out into the field to experience something of the discomfort, exhilaration and fear of the people who traversed and found the crevasse-free highways we travelled over. My diary is full of revelation – some of it basic ('holy cow they must have been terrified!'), to humbled comprehension. I sat at Rumdoodle Lake and thought: this is what led 21-year-old Syd to write, on January 16th 1956: 'I don't think I could ever stop trying to get people to come and see this. It makes me feel that it should be the reward for a long life well spent rather than be a gift so early in a life not so well spent'.

By journey's end I had drafted five of the nine chapters and every word I've written since I arrived home is informed by my recollection of being somewhere, in that wondrous frozen land. I have a sense of the place and I can tell the story of movement through it, because it has become real, familiar, a genuine character in the story. I can't wait to capture the entire first draft, to get a completed version of Syd's life in Antarctica. I'll be thinking of my fellow expeditioners and the people who made my trip possible – knowing that they are waiting for the next instalment is pushing me on.

There is something about the life-threatening dark side of the beautiful still land that awakens self-realisation. Everyone should see Antarctica, or at least read books, see movies or enjoy photographs of it. It's a wickedly wise place and only a fool learns its lessons slowly.

LYNETTE FINCH
Australian Antarctic Arts Fellow 2008

IN BRIEF

Change of Government

A federal election in November 2007 resulted in a change of government, with a new Prime Minister, new ministers and new government departments. The Australian Antarctic Division is now part of the Department of the Environment, Heritage, Water and the Arts and the responsibility of the Minister for the Environment, Heritage and the Arts, Mr Peter Garrett.

Pew Fellowship

A flexible fisheries model that provides for an ecosystem approach to krill management will be the focus of Dr Andrew Constable's research this year, after he was awarded the prestigious 2008 Pew Fellowship in Marine Conservation.

Dr Constable's research, conducted through the Australian Antarctic Division's Southern Ocean Ecosystems program, will ensure that the rapidly growing Antarctic krill fishery will not impact negatively on the recovery of threatened whale populations or the survival of other Antarctic creatures.

'As factors such as predator numbers, krill abundance and climatic conditions change over time, this computer-based model will allow us to see the impact of tightening or loosening krill fishery restrictions so that we can minimise negative effects on the Antarctic ecosystem,' he says.

GLENN JACOBSON

Dr Andrew Constable

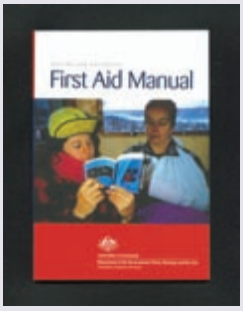
Australia Day Awards

Australia Day Awards were this year presented to the 26-member Australian Delegation to the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR). The team was made up of members from a number of government departments and industry groups, including 11 from the Australian Antarctic Division. The award recognises the delegation's significant contribution to the conservation of Antarctic Marine Living Resources through their individual and collective efforts in CCAMLR and its Scientific Committee.

Antarctic Division sea ice scientist, Dr Tony Worby, was also recognised for his role as Chief Scientist and Voyage Leader of the highly successful Sea Ice Physics and Ecosystem Experiment, conducted between September and October 2007.

New pocket 'doctor' for first aid in Antarctica

Expeditioners in the Australian Antarctic program (AAp) now have a new pocket guide to first aid to call upon. The seventh edition of the Australian Antarctic First Aid Manual, released in April, provides a succinct yet comprehensive guide to managing most conditions encountered in Antarctica, such as frostbite, broken bones, altitude sickness and appendicitis. The manual was authored by former Senior Medical Officer, Dr Peter Gormly (now retired), of the Australian Antarctic Division's Polar Medicine Unit (PMU), with contributions from past and present medical officers in the PMU.



Because of the remote and hostile nature of Antarctica the manual includes advice and procedures beyond the usual limits of first aid, such as stitching up wounds and administering injections and oxygen. The manual builds on and updates medical advice incorporated in previous editions – the first of which was published in 1979 as the ANARE First Aid Manual. The new edition takes into consideration new Australian Resuscitation Council Guidelines, updated cold injury management guidelines, changes in AAp medical support kits, and includes new chapters on mental health first aid and recognition of altitude illness in the deep field. More information: medicine@aad.gov.au

World Meteorological Day

Australian meteorological staff in Antarctica released a weather balloon from the historic balloon shed at Wilkes (near Casey), to commemorate World Meteorological Day on 23 March. The theme for this year's event was 'Observing our Planet for a Better future', which underscored the importance of monitoring meteorological and hydrological phenomena to help countries achieve sustainable economic development.

World Meteorological Day commemorates the entry into force of the World Meteorological Organisation, which is designated as a specialised agency of the United Nations System. More information: www.wmo.int/pages/wmd/index_en.html

TODOR TOLOVSKI

Tom Delfatti releases a commemorative weather balloon from the old Wilkes balloon shed to mark World Meteorological Day.

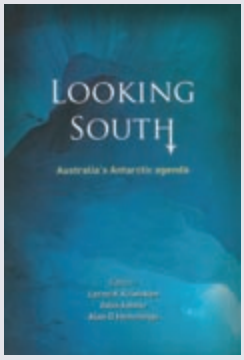
Vale Edith Fanta

On 7 May 2008, Dr Edith Fanta of Brazil lost her battle with cancer. Dr Fanta was well known in the Antarctic science community and served with distinction in both the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) and the Scientific Committee on Antarctic Research (SCAR). She was the Chair of CCAMLR's Scientific Committee from 2005 until her death. Her dedication to Antarctic science and her enthusiasm for the work of SCAR and CCAMLR were considerable. She was a friend to us all and will be greatly missed.

Advice-bound in Antarctica

Twenty years ago Peter Beck, a well published observer of Antarctic affairs, described Antarctica as 'a continent surrounded by advice'. While somewhat tongue in cheek, it is true that there is no shortage of ideas to guide the response of Antarctic policy makers to the unique challenges of Antarctic affairs. Two recent books illustrate the point – one from the perspective of the environmental lobbyist, the other from that of academic commentators.

In his book *Antarctica: securing its heritage for the whole world*, Geoff Mosley makes the case for inscribing Antarctica on the World Heritage List. The book recognises past achievements in Antarctic environmental protection, but argues that these measures fall short without Antarctic World Heritage listing. Antarctic Treaty parties would not disagree about Antarctica's values, but are skeptical of the application of the World Heritage convention – they take the stance that because of the special legal and political circumstances of the Antarctic, special arrangements need to apply. Mosley takes a more optimistic view and suggests options for overcoming the likely objections.



Looking South: Australia's Antarctic agenda is an edited collection of papers presented at seminars that looked at Antarctic policy from the Australian perspective. The project reflected on the 20 years that had passed since the publication of *Australia's Antarctic policy options* in 1986 and considered the way ahead. The papers examine issues relating to Australian approaches to Antarctic policy issues, such as sovereignty, influence in the Antarctic Treaty, enforcement of law in Antarctica, scientific challenges, climate change, management of tourism, and Southern Ocean fishing.

Both volumes address contemporary issues relevant to policy-makers and illustrate the range of perspectives that inform the development of Antarctic policy. Through forums such as the Antarctic Treaty, such commentary can influence how the international community responds to Antarctic issues. While many issues may not have simple solutions, the advice that surrounds Antarctic affairs demonstrates the willingness of others to engage positively in Antarctic policy debate.

Geoff Mosley's book is published by Envirobook in the Viewpoints series *(www.envirobook.com.au)*. *Looking South* is published by Federation Press *(www.federationpress.com.au)*.

Correction

On page 28 of Issue 13 of the *Australian Antarctic Magazine* a photo was incorrectly captioned as being of Don Butling when it was actually Don's colleague, Harry Black. The editor apologises for this mistake and thanks Don for providing a new photo (right).

Candle power for Earth Hour

TODOR IOLOVSKI

Expeditioners at Casey prepare for Earth Hour.

Australia's Antarctic stations were lit by candle power for one hour during Earth Hour on Saturday 29 March. The Earth Hour initiative, which aims to raise awareness of the contribution of coal-fired power to greenhouse gas emissions, originated in Sydney last year. Staff on our Antarctic stations are always seeking ways to reduce energy consumption and minimise waste. For example, equipment and lights are turned off when not in use, wind turbines at Mawson reduce the station's reliance on fossil fuels, solar power is used at Davis in summer for hot water and the laundry, and powdered and concentrated food and drink are used to reduce plastic packaging.

75 years of the Australian Antarctic Territory

FRANK HURLEY

Mawson's team claim Proclamation Island for the Crown – January 1930.

February 2008 marked the 75th anniversary of the Australian Antarctic Territory (AAT). At approximately 5 800 000 sq km in size, the AAT is the largest territorial claim on the continent and covers much of east Antarctica.

The Australian claim is based on discovery and a long historical association with this part of Antarctica. South Australian geologist, Douglas Mawson, led the 1911-1914 Australasian Antarctic Expedition, which established bases at Commonwealth Bay and the Shackleton Ice Shelf. The expedition explored extensively along the coast and claimed the land as British territory. From 1929 to 1931 further claims to sovereignty were made by the British, Australian and New Zealand Expedition, again led by Douglas Mawson.

On 7 February 1933, the British Government issued an Order-in-Council, placing the Territory under the authority of the Commonwealth of Australia. To give effect to the Order-in-Council the Australian Parliament passed the *Australian Antarctic Territory Acceptance Act 1933*. The Act came into operation by Proclamation in 1936. Adélie Land was defined in 1938 as comprising the area between 136°E and 142°E and, accordingly, the AAT comprises two 'sectors'.

The Australian Antarctic Division website www.aad.gov.au/default.asp?casid=34224 has a range of images, maps and documents from the early expeditions, video footage of Douglas Mawson reading a proclamation, and links to further information on the Antarctic Treaty.

This photo was taken in early spring, just as the Weddell seal pups were being born. During a trip out to Herring Island we discovered over 20 seals with their pups on the southern side of the island. After photographing some of them, I came across a recently used breathing hole. Wanting a picture of a seal emerging for air, I waited for about 10 minutes before one came to the surface. When it did, it blew a huge spray of water, before turning and looking right at me. I only had time to shoot one image before the seal slid silently back into the icy depths.

FREEZE FRAME

Chris Wilson worked at Casey and Davis stations as the Australian Antarctic Division's Building Services Supervisor between 2006 and 2008. He is now working as an estimator and project manager for Fairbrother Pty Ltd. Chris aims to produce photographs of a high technical standard, which document the constantly changing landscape of Antarctica, but that maintain their unique aesthetic quality.

ANTARCTICA valued, protected and understood

Australian Government
Department of the Environment, Water, Heritage and the Arts
Australian Antarctic Division

www.aad.gov.au