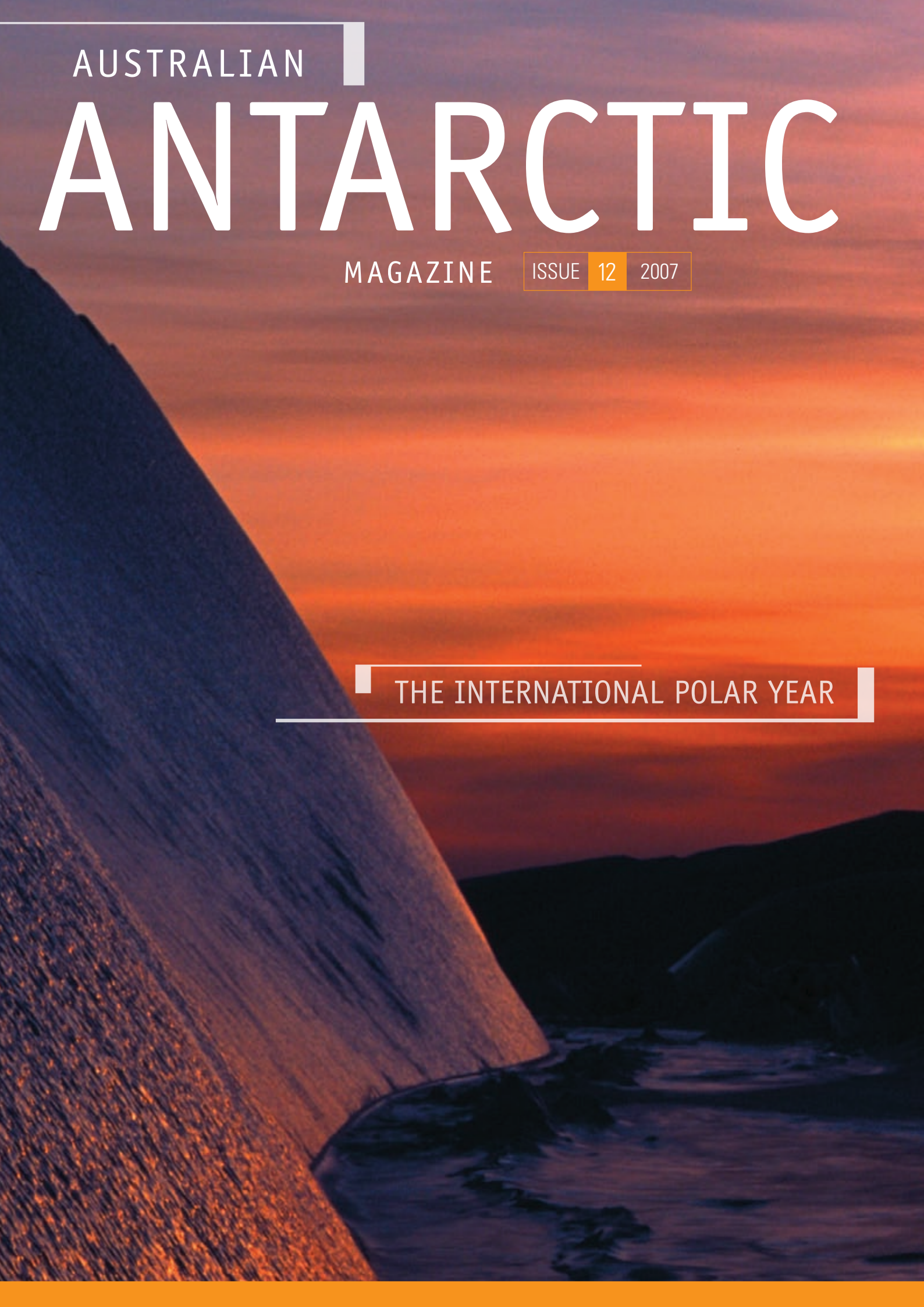

AUSTRALIAN ANTARCTIC MAGAZINE

ISSUE 12 2007

THE INTERNATIONAL POLAR YEAR

AUSTRALIAN
ANTARCTIC
MAGAZINE

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The Australian Antarctic Division (AAD), an agency of the Department of the Environment and Water Resources, leads Australia's Antarctic programme 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 programme, maintaining four permanent Australian research stations, and conducting scientific research programmes 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 programme. Opinions expressed in *Australian Antarctic Magazine* do not necessarily represent the position of the Australian Government.

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Australian Government
Department of the Environment and Water Resources
Australian Antarctic Division

FRONT COVER: SEAN WICKS

WELCOME TO THE INTERNATIONAL POLAR YEAR

CHRIS WILSON

On 1 March this year the Australian Antarctic Division (AAD) joined others around the world to celebrate the start of the International Polar Year (IPY).

Co-sponsored by the International Council for Science and the World Meteorological Organisation, the IPY will bring together thousands of scientists from over 60 nations investigating a wide range of physical, biological and social research topics in the Arctic and Antarctic. Focussing attention on the poles in this way encourages international scientific collaboration and the pooling of resources, providing opportunities for research that may not otherwise be possible and increasing the prospect of significant scientific advances.

Expectations of the IPY are high given the success of its predecessor – the International Geophysical Year (IGY) of 1957-58. The IGY saw major advances in the physical sciences, established the modern *modus operandi* in Antarctica, and led to negotiation of the Antarctic Treaty.

The IGY in turn followed two successful IPYs; the first in 1882-83 and the second in 1932-33. However, unlike these earlier events, which focused on the Arctic, the IGY was the first major international scientific effort focused on Antarctica.

Fifty years on, the fourth IPY (which will run until March 2009) promises to provide, among other things, critical insights into the environmental and social impacts of climate change at both poles. Other goals of the IPY include a legacy of enhanced observation networks and facilities for future research; access to data and information about the polar regions; the inspiration of a new generation of polar scientists; and public engagement in polar science.

The Australian Antarctic Division is leading four IPY projects, co-leading three, and participating in more than 40 other international projects. This issue of the *Australian Antarctic Magazine* features some of these projects, including the first marine research voyage for the AAD-coordinated Census of Antarctic Marine Life. The voyage provided the first exciting glimpses of long-hidden seabed life under the recently collapsed Larsen ice shelf (page 6).

This issue also looks at other Australian-led IPY projects and considers the logistical support required to undertake Antarctic operations during the IPY; while our Antarctic Arts Fellows – Network Ten's *Totally Wild* team – describe their experiences filming stories that will engage young people in Antarctic science – a major goal of the IPY (page 21).

Moving on to other activities, this issue features some early results from a recent marine science voyage to the sub-Antarctic. The voyage focused on the topical issue of carbon uptake by the Southern Ocean, and the effect of increased acidification of the water on tiny marine plants and animals. Professor Russ Hopcroft, a visiting scientist from the University of Alaska, provides some stunning images of the life forms that may be threatened by these changes (page 28).

We also look at three projects funded through the new Australian Centre for Applied Marine Mammal Science, headquartered at the Australian Antarctic Division. Research through the Centre will fulfil part of our broader marine mammal research and advisory role within the new Department of the Environment and Water Resources (formerly the Department of the Environment and Heritage).

I hope you enjoy this issue of the magazine and look forward to telling you more about our exciting IPY research in the next one.

Tony Press

A.J. PRESS
Director, AAD

©INTERNATIONAL POLAR FOUNDATION – PHILIPPE GOSSERIES

Dr Ian Allison of the Australian Antarctic Division and the Antarctic Climate and Ecosystems Cooperative Research Centre, speaking at the IPY launch in Paris on 1 March.

CELEBRATING A COMMON VISION

MARTIN LIPMAN

International cooperation, the inspiration of a new generation of polar scientists and world citizens, and the need to further the global understanding of climate change, were universal themes expressed by countries around the world at the launch of the International Polar Year (IPY) on 1 March.

The official International Opening Ceremony of the IPY took place at the Palais de la Découverte science museum in Paris. Hosted by the co-sponsors of the IPY – the International Council for Science and the World Meteorological Organisation – the ceremony included a press conference, exhibits and a live webcast from both poles. Executive Director of the International Council for Science, Dr Thomas Rosswall, highlighted the internationally collaborative and ambitious nature of the IPY.

'In comparison with previous polar years we have planned a broader programme involving all the relevant disciplines, from both natural and social sciences. The IPY is an excellent example of strengthening international science for the benefit of society,' he said.

Australian Antarctic Division (AAD) glaciologist and IPY Joint Committee Co-Chair, Dr Ian Allison, also spoke on the scientific, collaborative and human legacies arising from the IPY, including new and improved observing systems, better methods of information exchange, and increasing public awareness of polar issues.

In Australia, the Minister for the Department of the Environment and Water Resources, Malcolm Turnbull, spoke to the AAD via a video link from Canberra, on the importance of the polar regions

Members of the Turtle Island Tourism Group perform at the IPY launch in Canada.


JACOB HALASKA

A 1500 m³ helium-filled weather balloon was launched as part of Sweden's IPY opening ceremony.

in the global climate system and the need to further our understanding of this system.

'There are still large gaps in our knowledge and many crucial questions to be answered to help us prepare for the climate change challenges ahead,' he said.

'The International Polar Year, the largest international polar research programme for 50 years, could not be better timed with global climate a key issue around the world.'

AAD Chief Scientist, Professor Michael Stoddart, also outlined the four AAD-led IPY projects: the Census of Antarctic Marine Life, Aliens in Antarctica, Taking the Antarctic Arctic Polar Pulse, and Solar Linkages to Atmospheric Processes.

Questacon, Australia's National Science and Technology Centre, launched Project IGLO (International Action on Global Warming) in the Asia Pacific region. The project aims to raise awareness of climate change and is the result of collaboration between international science centres and museums.

The Royal Society of Victoria in Melbourne hosted a day-long symposium involving past and present Antarctic expeditioners, scientists and secondary school students. The Society expects to coordinate a voyage during the IPY, giving year 11 science students a taste of scientific research in Antarctica.

Students and teachers in Australia and around the world were also encouraged to join in the 1 March celebrations with a range of activities including experiments with ice, snow and water, and launching a virtual balloon.

Earlier in the week, at the European Parliament in Strasbourg, policy makers and leading scientists discussed how the international scientific community would work together during the IPY to address the threat of climate change and explain why polar science is crucial to understanding how the world works. More than 24 European nations are taking part in the IPY, investing some AUD$325 million in IPY science, education and outreach projects.

'The polar regions are vital arenas for science, foreign policy, trade, energy and security,' said Professor Carlo-Alberto Ricci, Chairman of the European Polar Board. 'International Polar Year is a once-in-a-lifetime opportunity for Europe to deepen and broaden international partnerships and create trust and mutual understanding through political and scientific dialogue.'

The UK celebrated its launch at the Royal Society in London in the presence of Her Royal Highness Princess Anne. Speakers at the launch noted the need to address the uncertainties highlighted in the Stern Review and the Intergovernmental Panel on Climate Change report on the contribution of the polar regions to future climate change and sea level rise.

At the National Academy of Sciences in Washington, US, 400 people gathered to view a video on the polar regions and a polar art exhibition, while a panel of polar scientists provided an in-depth discussion of ongoing and new research. A month earlier, scientists at the South Pole had kicked off the US IPY effort by collecting the first test observations of a new telescope – initially aimed at Jupiter. Researchers from nine institutions will use the telescope to unravel the fundamental mysteries of modern cosmology and the nature of the universe.

MERRYN MCKINNA – QUESTACON

In Canberra, Questacon's Manager of Education and Research, Merryn McKinnon, welcomes guests to the launch of the IPY and Project IGLO.


JOHN GILLIES

Former Australian Antarctic Division Director, Dr Phillip Law, cuts an IPY cake at the Royal Society of Victoria launch event.


MATHEW OAKES

Staff and guests of the Australian Antarctic Division celebrate the IPY launch.

Celebrations continued throughout March across some 20 nations including Denmark, Sweden, Argentina, Germany, Canada, Japan and Spain. Details of the events in other countries can be found at www.ipy.org and www.arcticportal.org.

Wendy Pyper
Information Services, AAD

AROUND THE WORLD IN 365

The International Geophysical Year (IGY) of 1957-58 was one of the most significant events in the human history of the Antarctic – it defined the role of science and the way it is conducted in Antarctica.

IGY followed in the tradition of a central role for geophysics in scientific research, which began with the 1829 voyage of Henry Foster in *Chanticleer* to measure gravity and magnetic features, and continued with the search for the South Magnetic Pole in the mid-19th century.

The idea for IGY arose during dinner in honour of the renowned physicist Sydney Chapman, at the home of James van Allen (after whom the Van Allen Radiation Belt is named). In 1950 the idea was formally proposed to the International Council of Scientific Unions, which welcomed it and established an organising committee. From the beginning the programme was to be purely scientific, with no concern for politics or finances, which would be the responsibility of participating nations.

The IGY was to be the third international polar year, following those of 1882-83 and 1932-33, and coincided with a peak in sunspot, and hence auroral, activity. The programme included upper atmosphere and cosmic ray physics, meteorology, seismology, glaciology, and gravity and magnetic studies. It was soon recognised that the phenomena to be studied had global relevance and, in 1952, the terms of reference were widened to take these into account. The name 'IGY' reflected the focus on physical sciences. Prominent modern disciplines such as geology, biology, oceanography and cartography were not included, although countries active in the IGY used existing facilities to conduct their own research in some of these non-geophysical disciplines.

The IGY was the first major international scientific effort with a dedicated Antarctic component. The first polar year in 1882-83, involving 12 nations, had 15 expeditions but only two in the Southern Hemisphere – at Orange Bay in southern Tierra del Fuego and one on South Georgia. The year recognised that the study of global meteorology and geophysical phenomena required large scale international collaboration, and thus set a precedent for collaborative work. The second polar year, involving 40 nations, investigated the global implications of the newly discovered jet stream, and saw advances in meteorology, magnetism and atmospheric science.

In the spirit of these collaborative successes the IGY involved 67 nations. Research was conducted at a time when many aspects of Earth's magnetic field were unknown, and continental drift was not widely accepted. Our modern understanding of the origin, structure and evolution of the ocean

As part of its programme of educational outreach, the National Academy of Sciences IGY committee put together a booklet providing a brief introduction to the earth and environmental sciences. The booklet was organised around six posters, each devoted to an area of geophysics and created expressly for the outreach project. This poster, ***Sun & Earth****, illustrated the current scientific understanding of the sun, its interactions with Earth, and the equipment used to study solar phenomena. The posters can be downloaded from www7.nationalacademies.org/archives/IGYPlanetEarthPosters.html. Films about the IGY can be viewed at http://lasp.colorado.edu/igy_nas/.*

DAYS

floor was in its infancy, and thus the programme would be seen in retrospect as concentrating on a narrow spectrum of what constitutes geophysics. The link between the magnetic features of the outer atmosphere and the inner reaches of Earth was unknown, but suspected. By the end of the IGY, scientists had discovered the Van Allen Radiation Belt, launched the world's first satellites (including Sputnik), made informed estimates of Antarctica's ice mass, and confirmed the theory of continental drift.

The IGY set in place the modern *modus operandi* in the Antarctic, including internationally coordinated scientific and logistic programmes, and long-term observatory studies. The days of the dedicated amateur or one-off adventure were over; from this time on, programmes were dominantly national. In addition, nations had to abide by evolving, internationally recognised scientific standards.

The IGY also addressed the need for stations in Antarctica, to support the research effort. Several nations, including Australia, already had stations operating in Antarctica, and many expanded their presence with the IGY in mind. Australia had established stations at Mawson in 1954 and Davis in 1957 – in preparation for the IGY. The United States built many stations including Wilkes, which eventually evolved into Australia's Casey station, and the USSR built Mirny and Vostok and shorter-term bases in the Australian Antarctic Territory.

While IGY was entirely scientific at the outset, the consequences of the international cooperation explicit in the programme were of far greater consequence in the long run, as it led to two globally significant initiatives:

- negotiation of the Antarctic Treaty (see box), which gave science a pivotal role in the affairs of the Treaty; and
- establishment of the Special (now Scientific) Committee on Antarctic Research (SCAR) in 1958 by the International Council of Scientific Unions, to coordinate multilateral science in Antarctica.

The IGY contrasts in many ways with the current IPY. The IGY was a *global* programme, focused fairly narrowly on geophysics. The IPY is concerned primarily with *polar regions* and with a very wide range of disciplines, including strong social, cultural and educational components. It would be gratifying to think that the IPY could, following the example of the IGY, lead to something greater than just the research that is currently envisaged.

Patrick G. Quilty AM
Honorary Research Professor, University of Tasmania

Antarctic Treaty makes IPY mission possible

The International Polar Year (IPY) is said to represent 'one of the most ambitious coordinated international science programmes ever attempted'. But cooperation in Antarctic science is nothing new. In fact, the IPY marks the jubilee of the 1957-58 International Geophysical Year (IGY), which was characterised by large scale scientific cooperation in Antarctica (see main story).

However, we cannot take scientific collaboration for granted. After the recent launch of the IPY it is timely to consider the history of scientific cooperation in the Antarctic, and the legal and political framework that makes such cooperation possible.

Interest in Antarctica grew rapidly during the first three decades of the 20th century, as scientific curiosity replaced geographical discovery. After the Second World War, this interest coincided with the efforts of several nations to consolidate territorial claims on the Antarctic continent. The continent was being mapped and built upon, but knowledge of it was still surprisingly scant. The International Council of Scientific Unions capitalised on this growing presence in Antarctica and, unlike previous polar years, made Antarctica the focus of the IGY.

Nations active in Antarctica soon realised that the value of IGY research would be undermined if they were pre-occupied with defending their sovereign concerns. So they agreed to set aside their sovereign interests during the IGY, allowing science to proceed unfettered by the boundaries marked on maps. The remarkable thawing of the 'Cold War' in Antarctica encouraged the 12 nations who had supported the research programmes to perpetuate this spirit of cooperation and tolerance.

Negotiations commenced on an international agreement to cement this cooperation. In December 1959 the 12 nations adopted the text of the Antarctic Treaty, which declared that Antarctica should forever be used for peaceful purposes and remain free of scientific or international discord. The Treaty prohibited nuclear explosions and the disposal of radioactive wastes, guaranteed scientific cooperation, and obliged the free exchange of the scientific results. The Treaty also accommodated differences over territorial claims.

Following its entry into force in June 1961, the Treaty spawned the broader Antarctic Treaty system which offers a raft of instruments, measures, decisions and resolutions that together provide for the governance of the continent.

Since 1961, signatories to the Treaty have expanded to 46. From an instrument of just 14 articles, we now have a regime of measures addressing a range of issues. We also have science proceeding peacefully and productively.

Cooperation in Antarctic research now appears common sense and routine. The breadth of IPY activities in Antarctica is a manifestation of the legacy of the IGY and the vision of the original negotiators of the Treaty.

Andrew Jackson
Senior Policy Advisor, AAD

LONG-HIDDEN SEABED

New and unusual seabed life, hidden by the Larsen A and B ice shelves for thousands of years, has been revealed by the first marine voyage of the Census of Antarctic Marine Life – the lead Antarctic biodiversity project for the International Polar Year, coordinated by the Australian Antarctic Division.

The ice shelves, which collapsed 12 and five years ago respectively, covered about 10 000 square kilometres of seabed in the Weddell Sea off the Antarctic Peninsula. When an ice shelf collapses it allows light, phytoplankton, zooplankton, and the sea floor animals that feed on this plankton, to return to the region. The return of this flora and fauna, however, is often disturbed by the scouring of icebergs born from the ice shelf collapse. The disintegration of the Larsen A and B ice shelves therefore provides an opportunity to observe the little-known environment under the shelves, and its inhabitants, and to follow the different steps in the recolonisation process.

Using sophisticated sampling and observation equipment, 52 marine scientists from 14 countries onboard the German research vessel *Polarstern*, studied the physical ocean properties and the region's flora and fauna, from the surface waters to the sea floor – up to 850 m deep.

The research was conducted over 10 weeks between November 2006 and January 2007 and involved: investigating early recolonisation stages and the impact of iceberg scouring on biodiversity; sampling and analysing unknown communities and their physical environment; and assessing the effects of present and future climate-induced changes on marine life.

'The break-up of these ice shelves opened up huge, near pristine portions of the ocean floor, sealed off from above for at least 5000 years, and possibly up to 12 000 years in the case of Larsen B,' said Dr Julian Gutt, a marine ecologist at Germany's Alfred Wegener Institute for Polar and Marine Research, and Chief Scientist on the *Polarstern* expedition.

'Until now scientists have glimpsed life under Antarctica's ice shelves only through drill holes. The collapse of the Larsen shelves may tell us about impacts of climate-induced changes on marine biodiversity and the functioning of the ecosystem. This knowledge is fundamental to understanding ecosystem function and will advance our ability to predict the future of our biosphere in a changing environment.'

Using a Remotely Operated Vehicle – an underwater robot equipped with video cameras – the team found that sea floor sediments in the Larsen zone ranged from bedrock to mud and harboured a variety of fauna. There was less iceberg scouring damage than expected, and in shallower depths to about 220 m, scientists observed a surprising richness of species.

'Iceberg disturbance was more obvious north of the Larsen A and B areas, where icebergs more typically

In the area of the Larsen A ice shelf scientists found these large, slow-growing glass sponges, which must have existed before the disintegration of the ice shelf in 1995.

LIFE UNCOVERED

run aground,' Dr Gutt said. 'In those outer areas, at depths of about 100 m, we observed fresh ice scour marks everywhere and early stages of marine life recolonisation, but no mature communities. At around 200 m depth we discovered a mosaic of life at different stages of recolonisation.'

Among the surprises was an abundance of deep sea lilies, sea cucumbers and sea urchins at 200 m depth. These animals are more commonly found at around 2000 m where resources are scarce – conditions similar to those under an ice shelf.

Apparent newcomers to the region included dense patches of fast growing sea squirts, which likely colonised the Larsen B area after the ice shelf broke in 2002. In contrast, very slow-growing glass sponges were found at greatest density in the Larsen A area, where life forms have had seven more years to recolonise. Scientists believe a high number of juvenile glass sponges seen in the area probably indicate shifting species composition and abundance in the past 12 years.

Small clusters of dead clamshells found littering the ocean floor at 850 m depth, suggested the presence of a rare 'cold seep' – a sea floor vent spewing methane and sulphide. Seeps can create a temporary habitat for life in otherwise barren, inhospitable terrain, but when the seeps extinguish, the organisms that rely on them die.

Among hundreds of specimens collected, the team identified 15 potentially new species of shrimp-like amphipods, four new cnidarians (a group that includes corals, jelly fish and sea anemones) and two new species of octopus. The animals will be examined in detail to confirm whether they are indeed new to science. New species will be entered into the Census of Marine Life Ocean Biogeographic Information System database (*Australian Antarctic Magazine* 10: 22) and its Antarctic counterpart, the Scientific Committee on Antarctic Research Marine Biodiversity Information Network (www.scarmarbin.be).

Fisheries investigations were also conducted during the voyage. Eighty-five hauls showed the biomass of two Antarctic cod species has increased since a survey in 2003, while stocks of Blackfin and Mackerel Icefish have decreased. These results will contribute to fish stock monitoring and assessment under the Convention on the Conservation of Antarctic Marine Living Resources.

Australian Antarctic Division Chief Scientist and Census of Antarctic Marine Life (CAML) leader, Professor Michael Stoddart, said the knowledge gained from the *Polarstern* expedition is just the 'tip of the iceberg'.

'Insights from this and CAML's upcoming International Polar Year voyages will shed light on how climate variations affect ice-affiliated species living in this region,' he said.

The Australian Antarctic Division will coordinate a further 13 voyages during the International Polar Year, including a joint Australian-French-Japanese expedition in early 2008.

*Adapted from the **Polarstern** news release, 25 February 2007.*

MAP NO. 133533 © COMMONWEALTH OF AUSTRALIA

This map shows the Census of Antarctic Marine Life voyages planned for the International Polar Year, and the countries undertaking the work. Dark blue areas denote benthic (sea floor) sampling. Dashed lines indicate areas where plankton in the open ocean will be sampled. Additional nations are providing historical data on marine biodiversity. All data will be incorporated into a database at www.scarmarbin.be.

More information and images can be found at: www.awi.de; www.caml.aq; www.coml.org; and www.cousteau.org/caml.html.

© G. CHAPELLE, ALFRED WEGENER INSTITUTE 2007

The Remote Operating Vehicle was used to capture still images and video footage, and collect some samples, during the voyage.

© J. GUTT, ALFRED WEGENER INSTITUTE 2007

These deep sea cucumbers are abundant in the Larsen B area at depths of only 200 m. They are more commonly found at around 2000 m where resources are scarce – conditions similar to those under an ice shelf.

© C. D'UDEKEM, ROYAL BELGIUM INSTITUTE FOR NATURAL SCIENCES, 2007

*This new Antarctic amphipod crustacean is nearly 100 mm long and belongs to the genus **Eusirus**.*

UNDERSTANDING THE RO THE SOUTHERN OCEAN IN

Australia is coordinating an international, multi-disciplinary research programme during the International Polar Year that will provide the first circumpolar snapshot of the physical, biogeochemical, atmospheric and ecological environments in the Southern Ocean region.

Southern Ocean processes have a global reach. For example, ocean circulation and water mass formation[1] in the Southern Ocean regulate the storage and transport of heat, freshwater and carbon dioxide throughout the world's oceans. As a result, changes in Southern Ocean currents and sea ice can affect global climate. Thus, if we are to predict future climate change, we must understand how the Southern Ocean will both respond to and drive climate change.

While the past decade has seen a rapidly growing appreciation of the role of the Southern Ocean and Antarctica in the global climate system, a lack of observations continues to hinder attempts to understand how the region drives and responds to climate change and variability.

The International Polar Year (IPY) presents an opportunity to fill this gap. The Climate of Antarctica and the Southern Ocean (CASO) programme, led through the Antarctic Climate and Ecosystems Cooperative Research Centre and CSIRO Marine and Atmospheric Research, aims to obtain the first circumpolar snapshot of the physical environment of the Southern Ocean, and enhance understanding of the role of the Southern Ocean in past, present and future climate.

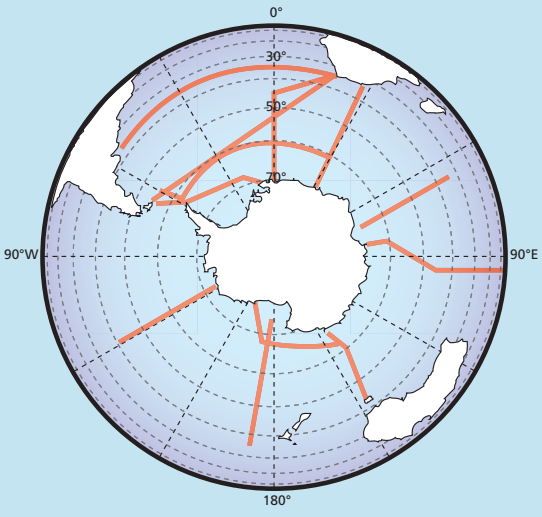
CASO includes 25 individual projects involving scientists from 18 nations, but it will also work closely with other IPY programmes, including studies of ocean circulation and ocean-ice interaction near the Antarctic margin, biogeochemistry, meteorology, ecology and paleoclimate.

Field work will include a range of new technologies such as:

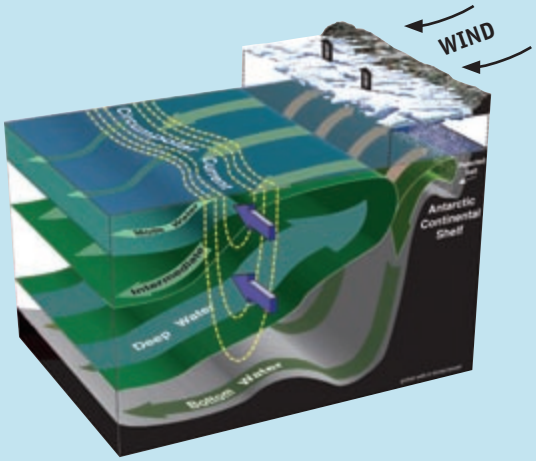
- A circumpolar array of 'sea ice drifters', measuring a range of ice, ocean and atmosphere parameters.
- Ocean profiling floats deployed to measure temperature and salinity throughout the Southern Ocean, including acoustically-tracked floats in ice-covered areas for the first time.
- Current meter moorings and pressure gauges to provide a time series of ocean currents and water mass properties.
- An expanded array of weather stations and atmospheric observations to measure atmospheric variability.
- Oceanographic sensors deployed on marine mammals, which will provide the first measurements of ocean conditions around Antarctica during winter.

Observations from these instruments will be closely integrated with a range of modelling studies.

Through this research, CASO will provide new insights into how the strong east-west flow of the Antarctic Circumpolar Current is linked to the Southern Ocean overturning circulation; determine



Voyage transects for the CASO programme will provide a synoptic circumpolar snapshot of the physical environment of the Southern Ocean that will enhance understanding of the role of the Southern Ocean in past, present and future climate.



CSIRO

The Southern Ocean overturning circulation carries layers of warm near-surface water and cold deep water in alternate directions, resulting in a net transport of heat (and other properties). This circulation is important for climate because it determines how much heat and carbon are stored by the ocean, and therefore the extent to which the ocean can slow the rate of climate change.

LE OF CLIMATE

the rate at which surface waters sink into the deep ocean and store heat and carbon dioxide; investigate the coupling between the ocean, atmosphere, sea ice, and ice shelves; and provide a more complete understanding of how Southern Ocean currents influence the carbon cycle, ecology and biodiversity.

As well as leading the programme Australia will make several other contributions to CASO. A major expedition to be carried out between November 2007 and February 2008 will include an oceanographic transect across the Antarctic Circumpolar Current, studies of Antarctic Bottom Water formation, and a survey of continental shelf waters as part of the Census of Antarctic Marine Life (story page 6).

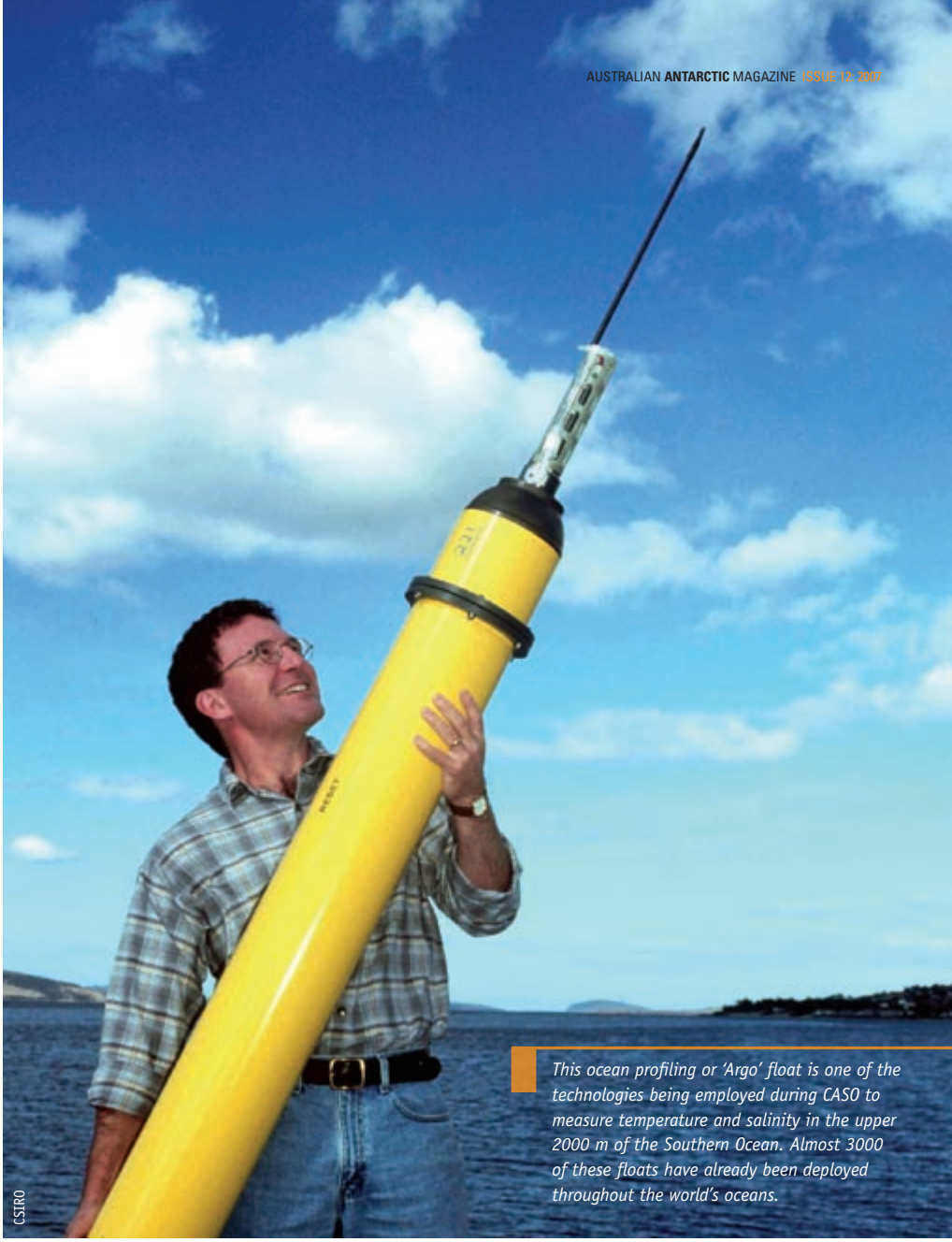
A winter expedition to the sea ice zone (page 10) will improve our understanding of the processes controlling the distribution and thickness of sea ice and of the algae and krill that live within the sea ice zone. Australia will also deploy oceanographic sensors on seals; deploy ocean profiling floats throughout the Australian sector of the Southern Ocean; measure how much carbon dioxide is being absorbed by the Southern Ocean; and contribute to international studies of mixing in the Southern Ocean.

The programme will result in improved climate predictions from models that incorporate a better understanding of southern polar processes. It will also provide a proof of concept of a viable, cost-effective, sustained observing system for the southern polar regions (including the ocean, atmosphere and cryosphere), and a baseline for the assessment of future change.

CASO plans and updated maps of proposed field work can be found on the Southern Ocean panel's web site www.clivar.org/organization/southern.

STEPHEN R. RINTOUL
CASO Programme Leader, ACE CRC and CSIRO

1 Water masses are bodies of water originating from a common source and having similar physical and chemical properties – such as surface waters cooled near the Antarctic continent, which sink to the deep ocean and become 'Antarctic Bottom Water'.



CSIRO

This ocean profiling or 'Argo' float is one of the technologies being employed during CASO to measure temperature and salinity in the upper 2000 m of the Southern Ocean. Almost 3000 of these floats have already been deployed throughout the world's oceans.

The Climate of Antarctic and the Southern Ocean programme is organized into five themes:

1. **Antarctica and the Southern Ocean in the global water cycle** will quantify the high-latitude contributions to the global water cycle; determine the sensitivity of the water cycle to climate change and variability; and identify the impact of changes in the high latitude water cycle on the rest of the globe.
2. **Southern hemisphere teleconnections** will study the climate connections between low and high latitudes; determine the role of air-ice-ocean interactions in southern hemisphere variability and change; and assess the sensitivity of the modes of variability to future change.
3. **Climate processes at the Antarctic continental margin** will improve our understanding and models of ocean-ice-atmosphere interactions and ice shelf stability; obtain a snapshot of the circumpolar distribution of the complex system of coastal, shelf and slope currents; quantify the production rate of Antarctic Bottom Water; and measure the circumpolar volume of sea ice.
4. **Climate–ecosystem–biogeochemistry interactions in the Southern Ocean** will aim to understand the impact of climate variability and change on Southern Ocean ecosystems, including the role of the Southern Ocean in the carbon dioxide cycle.
5. **Records of past Antarctic climate variability and change** will use proxy records from ice cores to determine the natural modes of climate variability on time-scales from years to millennia, and improve our understanding of the mechanisms of abrupt climate change in the past.

GETTING THE MEASURE OF SEA ICE

Scientists from eight nations will sail from Hobart to the sea ice zone east of Casey station (110-130˚E) in August, as part of Australia's contribution to the International Polar Year.

Over 55 days the multi-disciplinary sea ice voyage, jointly organised by the Australian Antarctic Division and the Antarctic Climate and Ecosystems Cooperative Research Centre, will investigate the links between sea ice physics, sea ice biology and the pelagic (open ocean) food web in the region, during early spring. This is the time of year when longer daylight hours cause the snow and sea ice to melt, and biological activity in the ice and underlying water to rapidly increase.

The scientific team will study processes on the ice surface, as well as within and under the ice, using a suite of cutting-edge technologies. These include airborne laser altimetry, snow radar, and a remotely operated vehicle (ROV) equipped with multiple sensors to study the environment directly under the ice.

The sea ice around Antarctica is important for a number of reasons. Firstly, it helps to drive global ocean circulation. When the sea ice forms, salt is excluded from the ice crystals, making the surface ocean waters denser and driving vertical circulation. To understand how this process might be affected by climate change we need to know whether the amount of ice that forms each year is changing. This means we need to know the thickness of the ice and the snow cover that sits on top of it.

Two new sophisticated airborne systems – helicopter laser altimetry and snow radar – will be employed to provide data from which we can calculate the thickness of both the ice and its snow cover. This will be the first time these two systems have been used over Antarctic sea ice, and the data we collect will help validate information received from new satellite sensors.

Surface measurements of the properties of the ice and snow cover will also form an integral part of this research programme, and scientists will measure snow and ice density and thickness on drifting ice floes, and conduct experiments and analyses in special freezer laboratories on the ship.

Sea ice also plays an important role in structuring Antarctic marine ecosystems and in the biogeochemical cycles of the Southern Ocean. It serves as a platform for marine mammals and birds, and provides a substrate for ice-associated communities consisting of various organism groups such as bacteria, algae and metazoans (larger, multi-cellular animals). In terms of biomass, these communities are generally dominated by algae, and their production accounts for up to 25% of overall primary production (photosynthesis) in ice-covered waters.


GRANT DIXON

Sea ice cores will be used to determine many properties of the ice, including its crystal structure, salinity and the composition of algal communities within it.

Sea ice communities provide an important food source for pelagic herbivores – such as krill and other zooplankton – during winter and early spring, when food supply in the water column is very low. Krill, a key species of Antarctic marine ecosystems, have been observed feeding on sea ice microbial communities, but it is still not known whether this is a major food source throughout the winter and over their entire geographic range.

The research team will use optical sensors on the ROV to measure the amount of algae on the bottom of the sea ice. A specially designed trawl net will also be used to sample the environment directly under the ice and will provide live krill that can be used for physiological experiments in the ship's laboratories.

The sampling programme will be complemented by an extensive sea ice coring and drilling programme, which together will increase our understanding of the physical and biological processes in the Antarctic sea ice zone and their effects on Antarctic climate and marine ecosystem function.

TONY WORBY
Ice, Ocean, Atmosphere and Climate programme, AAD and ACE CRC


BEN WALLIS

*The **Sea Ice Physics and Ecosystem Experiment** will investigate links between sea ice physics, sea ice biology and the pelagic food web.*

Taking the Antarctic Arctic Polar Pulse

The International Polar Year (IPY) provides a unique opportunity to study the health of polar expeditioners and other temporary resident populations in the extreme Antarctic and Arctic environments.

Taking the Antarctic Arctic Polar Pulse will be led by Australian Antarctic Division Chief Medical Officer, Dr Jeff Ayton. The project will develop an anonymous 'snapshot' database of health events occurring in the Antarctic and Arctic during the IPY using data collected through new and existing projects run by some 18 international polar research programmes.

The data will be used to investigate four key questions:

- What physiological, psycho-social and clinical changes occur in humans temporarily resident and interacting with the Antarctic environment?
- Are these changes comparable to those experienced in temporarily resident non-indigenous Arctic populations exposed to difficult environments?
- How can we best prevent and treat any adverse effects of these changes?
- How can this understanding enable us to improve the wellbeing of humans in polar regions, in space, in other extreme environments, and more generally?

Answers to these questions will also provide a greater understanding of the biophysical, clinical, cultural, social and behavioural processes that shape the sustainability of circumpolar societies.

The data will be gathered through a range of sub-projects, many of which have been underway for some time. These projects will benefit greatly by increased participation and cross-analysis of data across different countries, disciplines and at both poles. The projects include:

- *Nutrition and Body Composition in the Arctic*, led by Italy, which aims to anticipate malnutrition that could have physiological and psychological effects;
- *Dome A East Antarctica Psychology and Physiology Studies*, led by China, is investigating seasonal changes in mood and hormonal profiles;
- A French-Italian-led project looking at coping mechanisms, group dynamics, and psychosocial adaptation to isolation and confinement in a multicultural group;
- *Seasonal Activity Variations – Polar Regions*, led by New Zealand, looking at seasonal psychological patterns and activity levels of temporary residents in the Arctic and Antarctic.

The data will be collected from individuals on stations, ships, in field camps and on traverses. The database will provide a baseline reference for assessing the health of communities in extreme environments in the future.

Wendy Pyper
Information Services, AAD


MATT LOW

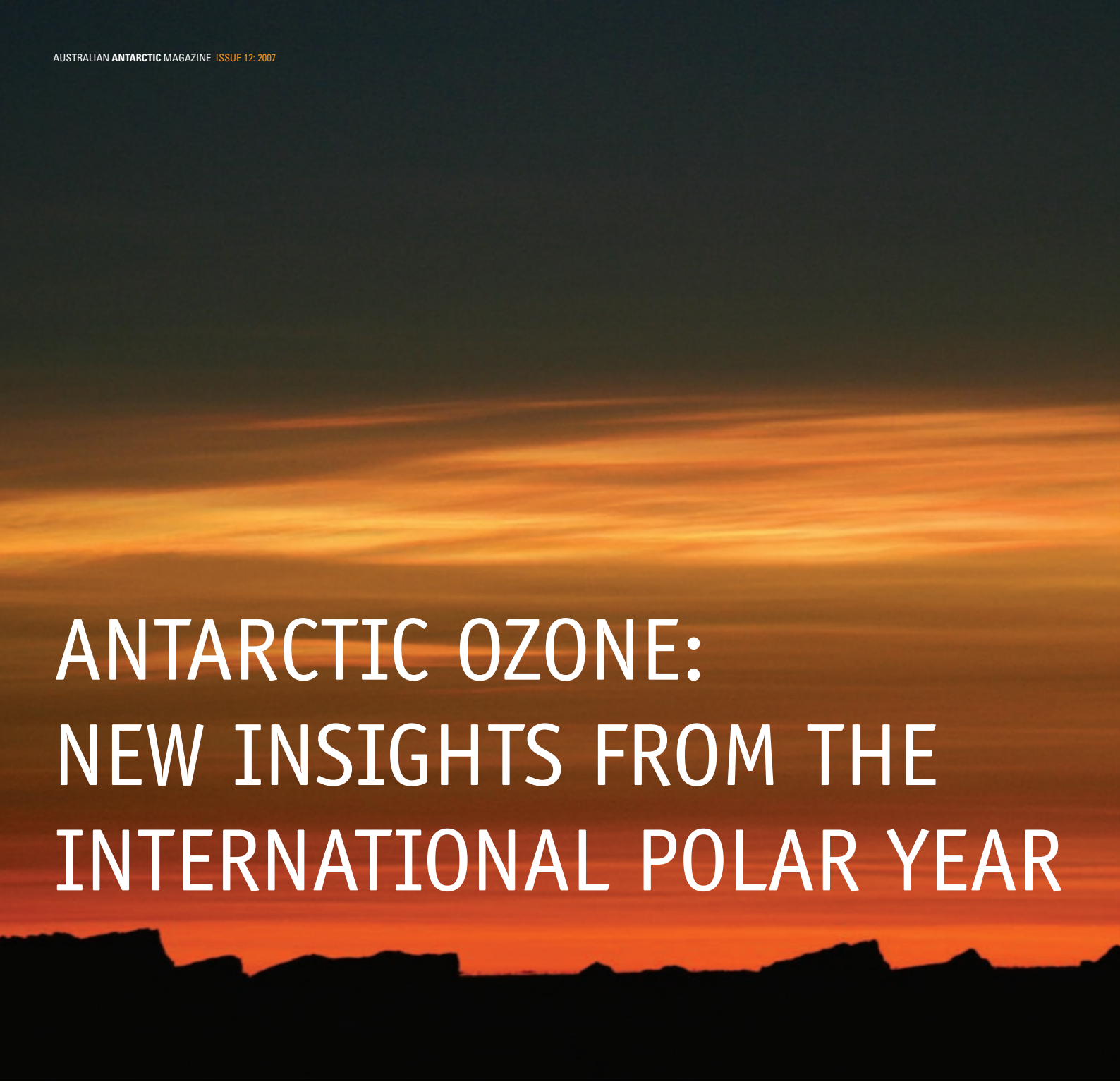
Taking the Antarctic Arctic Polar Pulse will study human health in extreme polar environments.

Aliens in Antarctica

As human travel continues to increase, the impact of the non-native (alien) species that they often accidentally carry with them, on ecosystems across the globe, is becoming one of the major environmental challenges of the 21st Century. The impact of these alien species ranges from minor transient introductions to substantial loss of biodiversity and ecosystem changes. Antarctica is not immune to the risks of invasive species, but impacts have so far been restricted to the milder sub-Antarctic islands. As parts of the continent warm, however, it will become easier for non-native species to gain a foothold. It is also now easier for humans (and their unintended living cargo) to travel to and around the Antarctic than ever before, and many more people are doing so. Focusing on the annual migration of scientists and tourists to the Antarctic in 2007, the Aliens in Antarctica project, led by Australian Antarctic Division scientist Dr Dana Bergstrom, will take samples from clothing and equipment, to provide a unique snapshot of the number of spores, seeds, invertebrates and eggs transported to the continent. This will be the first time that an assessment of the extent of transfer of alien species into an entire biome has been made.


KATE KIEFER

All people travelling to the Antarctic and sub-Antarctic will have their clothing and equipment inspected for potentially invasive alien species.



ANTARCTIC OZONE: NEW INSIGHTS FROM THE INTERNATIONAL POLAR YEAR

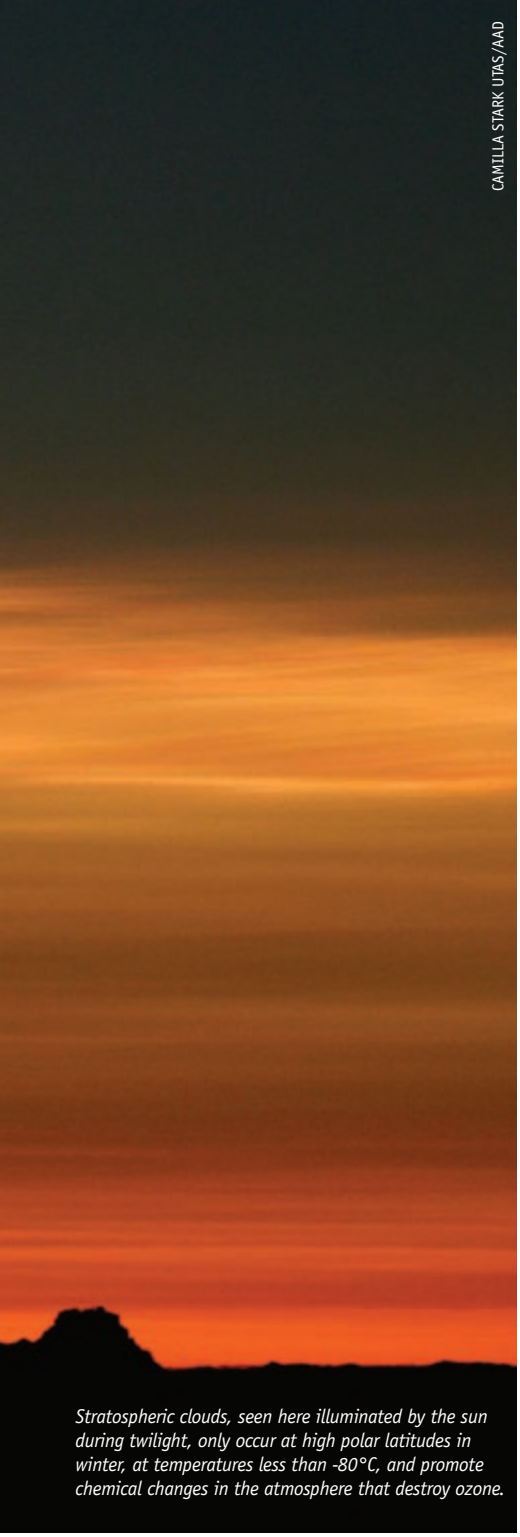
Australia is participating in an International Polar Year (IPY) project that will help improve future predictions of atmospheric ozone.

The ORACLE-O3 project brings together an extensive array of measurement and modelling approaches to shed new light on fundamental aspects of ozone loss and related processes in the polar regions.

There is considerable interest in Antarctic polar ozone owing to anticipation of the first significant signs of recovery in the ozone hole phenomenon. Since the 1980s, dramatic episodes of ozone destruction have occurred in the Antarctic stratosphere each spring, particularly between 12 km and 25 km above the Earth's surface. This phenomenon is directly related to the release, since the mid 1900s, of certain man-made ozone-depleting gases. There have also been smaller and less regular depletions over the Arctic in spring, as well as a general decline in ozone levels outside the tropics.

Ozone plays two important roles in the environment. Firstly, although ozone is only a very small part of the atmosphere, it acts as an efficient natural sunscreen, absorbing most of the ultraviolet sunlight that is harmful to life. Secondly, ozone influences the vertical structure of the atmosphere through heating and cooling processes. Thus, changing the natural level of ozone may directly influence ecosystems and climate.

In September 1987 the Montreal Protocol was signed to limit the production and release of ozone depleting substances. By the mid-1990s, levels of some harmful, man-made gases started to decline at the Earth's surface. However, because of their relatively long atmospheric lifetimes, levels of these gases likely peaked in the stratosphere only recently. Currently, the severity of spring ozone loss over Antarctica is dictated more by



CAMILLA STARK UTAS/AAD

Stratospheric clouds, seen here illuminated by the sun during twilight, only occur at high polar latitudes in winter, at temperatures less than -80°C, and promote chemical changes in the atmosphere that destroy ozone.

stratospheric temperatures during winter (with cold winters causing greater ozone loss) than by changes in the levels of the harmful gases. Our best assessment is that stratospheric levels of ozone depleting substances should now be declining, and the first signs of ozone recovery will appear around 2018. The return of Antarctic ozone levels to pre-1980 conditions will occur between 2060 and 2075.

Our appreciation of the importance of ozone is relatively recent. Identified as a naturally occurring atmospheric gas in the mid 1800s, it wasn't until the 1880s that the filtering affects of ozone on ultraviolet light was realised. By the 1920s the importance of ozone on climate was becoming apparent. Around this time, the first accurate methods were developed to measure the amount of ozone in the atmospheric column.

DIDIER MONSELESAN

Bureau of Meteorology observer Annette Schlub launches an ozonesonde balloon at Davis.

Ozone research accelerated during the International Geophysical Year (IGY) of 1957-58. Pioneering work identified the world-wide distribution of ozone and its seasonal behaviour, established modern ozone measurement protocols, and developed new analysis techniques. Australia played a leading role in the measurement programme, operating instruments at Macquarie Island, Aspendale (near Melbourne) and Brisbane. The only two Antarctic measurement sites were at Halley Bay and Argentine Island, both operated by the United Kingdom[1]. The measurements at Halley Bay provided crucial baseline information on spring ozone that enabled scientists to recognise the first signs of the Antarctic ozone hole

Fifty years on, we are investigating ozone-related processes that were completely unexpected during the IGY. As with many areas of IGY endeavour, the measurements made during that time have been invaluable in raising our awareness and understanding of environmental issues.

International ozone research during the IPY emphasises improving our understanding of ozone loss processes, so that predictions of future trends can be made with greater certainty. A key contribution of the ORACLE-O3 project to this effort will be the accurate measurement of atmospheric parameters, particularly over the poles where ozone is most sensitive to change. Part of this work will involve the release of balloon-borne sensors or 'ozonesondes' from more than 40 Antarctic and Arctic sites, to accurately measure the vertical profile of ozone and other meteorological parameters, to altitudes in excess of 30 km.

Scientists at Australia's Davis station will participate in efforts to track and make multiple in-situ measurements of ozone inside air streams moving around Antarctica. The work, coordinated by the Alfred Wegener Institute in Germany, will involve careful coordination of ozonesonde releases, and the collection of measurements by satellite and ground-based instruments. Researchers will also take advantage of the long-term ozone measurement programme currently operating on Macquarie Island.

Thanks to the networks of measurements sites, international data centres and space-based environmental monitoring systems inspired by the IGY, we are well positioned to attempt a more complete understanding of our natural environment, and leave a lasting legacy of precise measurements for the benefit of future scientists. Ozone research associated with the IPY will provide greater certainty about future climate, and confirmation that international cooperation in controlling the release of ozone depleting substances is improving the health of the atmosphere.

Andrew Klekociuk
Ice, Ocean, Atmosphere and Climate programme, AAD

Matthew Tully
Atmosphere Watch Section, Bureau of Meteorology

Further information

ORACLE-O3 Project
www.awi-potsdam.de/www-pot/atmo/ORACLE-O3

Scientists find Antarctic ozone hole to recover later than expected
earthobservatory.nasa.gov/Newsroom/NasaNews/2006/2006062922540.html

Australian Bureau of Meteorology
www.bom.gov.au/inside/oeb/atmoswatch/aboutozone.shtml

1 The Argentine Island station is now called Vernadsky, and is operated by the Ukraine. The Halley Bay site is near the location of the current Halley station. Ozone measurements at both of these stations continue today.

INTERNATIONAL ANTARCTIC INSTITUTE

The new International Antarctic Institute (IAI), established in July 2006, will welcome enrolments in its first international degree programme – a Masters in Antarctic Science by course work – in early 2008.


TOSHIHIRO YOSHIDA

International delegates gathered in Hobart to discuss establishment of the International Antarctic Institute.

With its secretariat being hosted by the University of Tasmania, the IAI is part of Australia's commitment to education and outreach during the International Polar Year.

The IAI will serve as an international educational centre for Antarctic programmes, with cross-accreditation of courses between participating institutions. Students will enrol in their home institutions and take up an agreed proportion of their course units at other IAI member institutions during their degree programme.

Members and associate members of the IAI presently include 20 universities and colleges from countries including Australia, Brazil, Chile, France, Germany, Italy, Japan, Malaysia, New Zealand, Norway, Spain, the UK and the USA. The University of Tasmania will host the institute's secretariat for the first developmental phase (three to five years) before it is rotated among partner institutions.

The major objective of the IAI is to produce expertly trained scientists and social scientists with international experience and skills in research and its application. The IAI will deliver the knowledge and information needed by our future scientists and policy-makers to address sustainable resource management, climate impacts and other global environmental and social issues associated with Antarctica and the Southern Ocean.

Patti Virtue and Andrew McMinn
IASOS, University of Tasmania

More information:
www.iai.utas.edu.au

Surfing the building technology wave

Expeditioners at Davis station now have a new place to chill out. A new library-cum-lounge room, built from the same material as surfboards, was delivered to the station last March, for commission next summer.

The new building is made of lightweight, durable 'fibre composite', or fibreglass and foam, which has unique insulating properties that boost the building's energy efficiency.

'The building is constructed of fibreglass encasing 200 mm thick blue foam panels of extruded polystyrene,' project engineer, Mark Pekin, said.

'This foam contains a lot more air pockets – and therefore insulating capacity – than white foam, or expanded polystyrene, which is predominately used as insulation for Antarctic buildings.'

To achieve similar insulation qualities, an equivalent concrete panel would need to be 1400 mm thick and therefore 15 times the weight.

The building also has 'dual double glazed' windows – four panes of glass – with automatic hollow-core blinds between the internal and external double glazed glass windows. This provides five layers of insulating air compared to the usual two layers in other Antarctic buildings with triple glazed windows.

The absence of a steel frame means the building is significantly lighter, allowing it to be manoeuvred into place with a crane. The whole building can also be assembled in Australia, reducing the risks and costs associated with construction in Antarctica. In addition, the fibre composite material can be moulded into any desired shape.

These characteristics provide engineers with greater flexibility in how they use and reuse such structures. For example, the new library-lounge can be easily moved, refitted, and if necessary, tipped on its side, to fulfil other purposes.

The prefabricated library-lounge – which measures 12.2 m long, 3.7 m wide and 2.6 m high – left Australia after a complete fit-out with electrical wiring, lighting, carpets and furniture. The foundations will be laid during the year, and the building should be ready for the first wave of visitors by Christmas.

Wendy Pyper
Information Services, AAD


MARK PEKIN

The prefabricated fibre composite building weighs about seven tonnes.

Davis station turns 50

Australia's Davis station celebrated its 50th anniversary on Saturday 13th January 2007.

At 1600 hours on January 13th 1957, work stopped and all hands assembled around a flagpole, which had been strapped to the wall of the first hut being erected. Phil Law made a short speech stressing the importance of the new station in the International Geophysical Year programme. This was followed by short account of achievements of Captain John King Davis, the singing of God Save the Queen, three cheers, and then back to work.

Davis was established on 13th January 1957, at the start of the International Geophysical Year, by an Australian National Antarctic Research Expedition party led by Dr Phillip Law – the founding Director of the Australian Antarctic Division. Aboard the *Kista Dan*, the party had spent days searching the coast off the Vestfold Hills for a good anchorage and source of fresh water. On 12th January a suitable spot was sighted – a small rocky terrace above a black sandy beach – and unloading of the ship and station building began.

The next day a small ceremony was held to officially establish Davis station, named in honour of Captain John King Davis, master of many historic Antarctic ships, including Douglas Mawson's 1911-14 Australasian Antarctic Expedition ship *Aurora*.

The first two years at Davis were devoted to gathering basic knowledge about the Vestfold Hills – one of the largest ice-free areas in Antarctica – and developing essential station services.

Davis was temporarily closed in January 1965 to allow concentration of the Australian Antarctic Division's resources on the building of Casey station. It was re-opened on 15th February 1969, and has operated continuously since then.

There are over 300 lakes in the Vestfold Hills, ranging from hypersaline to fresh water. In the 1970s a biology programme began, studying the lakes' microorganisms. As the programme developed, field huts were built at several sites in the Vestfolds, the first being Brookes Hut at Long Fjord in 1972.

In the 1980s Davis station was substantially upgraded as part of the rebuilding programme for all Australia's Antarctic stations. Davis has now become the premier Australian Antarctic research centre. It is the hub of investigations into the biology, geology and glaciology of the Lambert Glacier/Amery Ice Shelf region, and the home of a major atmospheric physics programme using laser technology to investigate the Antarctic stratosphere.

Davis is also the base for Australia's two C212-400 aircraft that deploy researchers and equipment to the less-accessible areas of the Vestfold Hills and remote coastal and inland areas beyond, undertaking aerial surveys and transferring personnel between Mawson, Casey and Davis.

Expeditioners marked the 50th anniversary with a group photo outside the original hut, similar to the first group photo taken in 1954. Celebrations included a telephone hook-up between Davis and Dr Phillip Law, now aged 94. In the spirit of international friendship, representatives from the nearby Russian station, Progress 2, and China's Zhong Zhan, were invited to share in the event.

A slide show of images of Davis from the 1950s to today, and a commemorative video and poster, are available on the Australian Antarctic Division's website at www.aad.gov.au.

Compiled by Information Services, AAD

AURORA AUSTRALIS CONTINUES HER ANTARCTIC SERVICE

Australia's Antarctic flagship, the bold, orange ice breaker, *Aurora Australis*, will ply the Southern Ocean between Hobart and Antarctica for another five years, under a new contract between the Australian Antarctic Division and P&O Maritime Services.

The contract was renewed after a competitive 'Request for Proposal' process, which attracted responses from around the world. It enables the Antarctic Division to use the ship for 180 days per year over the next five years.

Since 1989 the *Aurora Australis* has delivered personnel, supplies and equipment to Australia's Antarctic and sub-Antarctic stations, and carried intrepid marine scientists safely through the Southern Ocean rollercoaster.

Now docked in Hobart, the ship is undergoing a facelift, with refurbishment of cabins, recreational areas and laboratories, addition of a new marine laboratory on the trawl deck, and repairs to plumbing and telephone systems.

DOUG THOST

FROM HOBART TO ANTARCTICA AND BACK AGAIN

The Sea and Air Operations team has an exhaustive schedule ahead, during the International Polar Year.

Fast forward to October 2007, and the *Aurora Australis* is on its way back to Hobart at the end of a sea ice research voyage, undertaken as part of the International Polar Year (IPY). The ship will need to offload the marine scientists and their samples before loading the cargo, fuel and expeditioners for the next voyage to re-supply Casey and Davis stations. There is much to do while the ship is in port.

First up is to ensure that TASPORTS has obtained suitable berths for the ship. The ship will need to move at least three times in four days. Each time it becomes a pawn in the movements of the small but busy Hobart port. There are so many variables: the ship can't pass under the Tasman Bridge during rush hour; cruise ships get priority; some captains need tugs to get away from the wharf, others don't; and so it goes. The shipping agent will help navigate the berthing maze and will book the ship at the fuelling berth further up river. The next voyage will be delivering bulk fuel to Davis, and loading all that fuel takes time.

Due to the two long IPY marine science voyages this season, there will only be two voyages to the continental stations. Rather than making things easier, it puts a lot of pressure on the existing voyages. We will need to make sure that every bunk is taken and every piece of cargo space is utilised. Shipping remains one part of a complex equation of Antarctic logistics which encompasses station capacity, engineering capacity and aircraft. A good deal of planning will be required to integrate all these elements.

The new Voyage Leader and Deputy Voyage Leader need to be briefed – the resupply team will need to make sure the ship is back in Hobart at as close to the scheduled time as possible, to start the next IPY voyage on time. This will be a combined voyage for two IPY marine science programs, the Collaborative East Antarctic Marine Census (CEMARC) and Climate of Antarctica and Southern Ocean (CASO). Our returning Voyage Leaders must also be debriefed.

New TASPORTS security and safety procedures mean that marine scientists and others wanting to work on the ship while it's in port will need to undergo a safety induction. The new rules also mean that getting friends and family in to say goodbye is more difficult than it used to be.

NICKI CHILCOTT

NICKI CHILCOTT

TOP: Marine science cargo awaits loading on to the ship. BOTTOM: Quarantine inspectors and their dogs monitor cargo and personal possessions for plant and animal matter that could pose a hazard to the Antarctic environment.

NICKI CHILCOTT

Large and oddly shaped cargo, such as this Kässbohrer snow grooming machine being unloaded from the ship in Antarctica, can cause headaches for the cargo facility supervisor.

Repair and maintenance of the ship is critical. The crew can repair most things at sea but there are a number of repairs that are best done when she's alongside. Scheduling these in advance makes things flow more smoothly.

The science technical support section will focus on the laboratories and other scientific equipment on the ship. While the first marine science voyage is nearly over, the combined (and hence complex) CEMARC/CASO voyage is coming up quickly, and it will be critical to have all the ship's science equipment in working order. Sounds simple enough, but there could be conflicts with the loading, maintenance and other activities scheduled over the hectic few days.

The scientific samples on the returning voyage need special attention. Once they've been cleared for import by the Australian Quarantine Inspection Service (AQIS) they need to be stored and transported in the right conditions to preserve them for future analysis.

The cargo facility supervisor needs to develop a loading plan for the upcoming voyage, task the stevedores who load the ship, and schedule their shifts to get the ship loaded in the most efficient way possible. Cargo will be a bit of a headache. There is still a lot of big equipment to go to the new runway at Wilkins and some of it is oddly shaped. This makes the loading jigsaw even harder. Even though the voyage is less than a week away, some of the cargo is still to arrive and some of it won't be ready at all in time to get on the ship.

From an Australian Customs Service point of view there is no difference between exporting to Antigua and Antarctica, so all export items need to be declared through a comprehensive manifest process. Additionally there is the understanding the Australian Antarctic Division (AAD) has with AQIS that they will monitor our southbound cargo for potential introductions of alien species to the pristine Antarctic environment.

There are other things too. Organising passport and duty-free checks, helping expeditioners from overseas, briefing and debriefing ship's captains, last minute briefings for departing expeditioners… the list goes on.

There is always a lot going on when the ship is in port, IPY or not. Some things won't run to plan, something is bound to take longer or shorter than expected, and every change will affect at least two of the agencies involved. Fortunately, the AAD team enjoy the challenges of working in such a flexible environment, where no two days are ever the same.

David Tonna
Sea and Air Operations, AAD

SOLAR LINKAGES TO ATMOSPHERIC PROCESSES

Solar Linkages to Atmospheric Processes is an International Polar Year project investigating the links between changes in solar output, and weather and climate.

Ever since the early 1800s when William Herschel, the Astronomer Royal, noted an anti-correlation between the price of wheat and the number of sunspots, many researchers have reported apparent links between solar and weather-related variables. Unfortunately, the research field of solar-terrestrial linkages is littered with examples of poor statistical analyses. Many claims of correlations have been reported and almost as many have been refuted by additional data and further analysis.

The energy associated with variations in the sun's output are small compared with the total energy it supplies, and to the energy accumulated within the global weather system. As a result, a mechanism through which solar variations can influence the weather has been difficult to find.

A number of hypotheses linking solar variability and weather have been proposed, including through changes in ozone concentration and heating in the stratosphere, and fluctuations in energy output during the 11-year solar cycle. More controversially, cosmic rays (radiation from space) vary in intensity by about 15% over a solar cycle and have been reported to be correlated with cloud formation. A variation in cloud formation can influence weather and climate by altering the fraction of solar energy reflected or absorbed by the lower atmosphere.

Through the Solar Linkages to Atmospheric Processes project, scientists at the Australian Antarctic Division will look at one mechanism by which cosmic rays may be linked to cloud formation – the global atmospheric circuit.

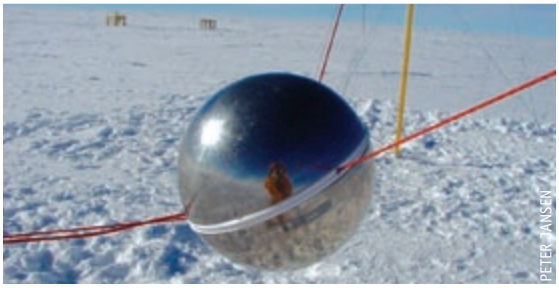
Lightning is the component of the global atmospheric circuit we are most familiar with, and is the visual representation of current flowing upwards to the thunderclouds. Thunderstorms are the 'batteries' in the global atmospheric circuit, which drive current from the ground to the lower reaches of the ionosphere, some 80 km above.

While thunderstorms and strongly electrified clouds are the dominant controllers of the global atmospheric circuit, in the polar regions the interaction of the solar wind and the Earth's magnetic field – the same process that leads to the aurora (seen here over Newcomb Bay at Casey) – also contributes to this circuit

The current returns from the ionosphere to the earth, completing the circuit in a less spectacular 'drizzle' over the portion of the globe not covered by thunderstorms. Cosmic rays dominantly control atmospheric conductivity and thus modulate the current that flows in the global circuit.

Scientists have proposed that the global atmospheric circuit influences cloud development by initiating a range of microphysical processes. These include electrical influences on the formation of cloud aerosols in the atmosphere, which may affect cloud lifetime, ice formation and precipitation.

GARY BURNS



PETER JANSEN

The Air-Earth Current Meter deployed at Vostok. This instrument measures the miniscule current (about 6 picoamps per square metre) flowing from the ionosphere to the ice through the suspended split-sphere. A picoamp is 10^{-12} of an ampere – approximately 160 000 000 000 times smaller that the current through a 60 watt light bulb.

CHRIS WILSON

While thunderstorms and strongly electrified clouds are the dominant controllers of the atmospheric circuit, in polar regions the interaction of the solar wind and the earth's magnetic field (the same process that leads to the aurora) also contributes to the atmospheric circuit.

Since 1998 we have been studying the atmospheric circuit at Vostok, in Antarctica, and have recently published a paper showing a link between the solar wind (charged particles streaming away from the sun's surface) and pressure at ground level. Additionally, our measurements demonstrated the enhanced influence of the global thunderstorms on pressure in a manner consistent with the cloud microphysics mechanism. If this hypothesis is confirmed, then the influence of this microphysics mechanism extends globally, via the atmospheric circuit and cosmic ray modulation. It also provides a link between equatorial thunderstorms and polar clouds.

Through our International Polar Year project, we will make measurements of the global atmospheric circuit on the Antarctic plateau, to increase our understanding of the links between the atmospheric circuit, solar variability and weather.

Instruments for measuring the atmospheric circuit at Vostok have recently been upgraded, and we hope to deploy further instrumentation at Concordia and South Pole. The British Antarctic Survey deployed instrumentation at two sites in Western Antarctica in 2006-07, and plans an additional deployment in 2007-08. Measurements at even these few sites will enable us to significantly improve our understanding of the global atmospheric circuit by resolving the major drivers (thunderstorms and the solar wind) and enable us to better test the hypothesis that the atmospheric circuit influences cloud microphysics.

The Electric Field Mill deployed at Vostok measures the vertical electric field (volts/metre).

A global circuit model is under continuing development and data from our project will be compared with model predictions, to confirm or refine our understanding of the processes involved. The global model will also enable us to extend our measurements, to better predict global and climate duration implications.

The atmospheric circuit is expected to be strongly influenced by climate change. Thunderstorm activity is strongly dependent on summer equatorial temperatures, and global lightning activity is expected to increase by the order of 10% for a 1°C increase in average temperatures. Measurements made during the International Polar Year of the annual-seasonal diurnal variations of the global contribution of the meteorological batteries, will provide a reference against which future climate variation can be determined.

GARY BURNS

More detail of the scientific aims of our project is provided at http://globalcircuit.phys.uh.edu/SLAP/SLAP_web_content.htm, which also includes updates of the most recent nine days of atmospheric circuit measurements at Vostok.

Gary Burns
Ice, Ocean, Atmosphere and Climate programme, AAD

AVIATION IN ANTARCTICA REACHES NEW HEIGHTS

Australia's new jet aircraft, which will provide an air link between Australia and Antarctica, made its first overflight of Wilkins runway, near Casey, in February.

Carrying a small, excited group of Australian Antarctic Division (AAD) staff, the Airbus A319 took nine hours to make the return flight from Hobart, which included a single pass over the four kilometre snow-capped ice runway and Casey station.

In the 2007-08 season the aircraft will make its first touch down on the Wilkins runway. Regular passenger service will commence in 2008-09, with flights carrying up to 19 passengers and cargo. The A319 is leased and operated by Skytraders Pty Ltd of Sydney, with an initial lease period of five years.

Aircraft will play an important role in Australia's aviation capability in Antarctica, particularly during the International Polar Year. Airlink flights and other Antarctic operations will be supported by AS 350BA helicopters, which have been operating in Antarctica since 1986, two C212 fixed wing aircraft, introduced in late 2004, and the Aircraft Ground Support Officers.

The 2006-07 summer flying season saw a mix of solid aviation support.

Helicopters

Operated by Helicopter Resources, the helicopters provide flexible ship and land-based support. In 2006-07, ship-based activities included:

- Multiple ice reconnaissance flights for the first voyage of the season, in October/ November, which identified a path through thick, early season sea ice to Casey, and enabled 42 expeditioners and 16 tonnes of cargo to be deployed in one day. Long distance fly offs of passengers and cargo would have jeopardised the chances of getting all priority project cargo ashore, and delayed progress on Wilkins Runway.
- Deployment of a team to Béchervaise Island; deployment of 39 Chinese expeditioners and 15 tonnes of cargo to Zhong Shan in one day; and delivery of 250 drums of aviation fuel to the Larsemann Hills in four and a half hours, in support of the German Antarctic programme.

Land-based activities included:

- Support of a number of glaciology projects on the Amery Ice Shelf, biological projects in the Vestfold Hills, and geological projects requiring camp moves and resupply in the Larsemann Hills, Brattstrand Bluffs, Rauer Islands and other locations on the Ingrid Christensen Coast.
- Search and rescue and field support to the Film Australia re-enactment of the 1912-13 Mawson sledge journey.
- Operational support for expeditioner field training, hut maintenance, fixed wing support, and goodwill visits to the Russian, Chinese and Romanian bases.

C212

Between November 2006 and February 2007 the two C212 aircraft, 'Ginger' and 'Gadget' completed about 300 hours of flying. Season highlights included the transfer of Mawson expeditioners and cargo to Davis and the recovery of camp and equipment from the Amery ice Shelf. Operations were also conducted over approximately 5000 km of Australian Antarctic Territory coastline in support of deep field biological and geophysical programmes. This included ski and wheeled operations to unprepared sea ice, blue ice and frozen lakes at various locations.

Aviation ground support

Aircraft Ground Support Officers are an invaluable addition to aircraft operations and our stations. Their tasks are varied and include assisting expeditioners, refuelling, documentation – such as cargo manifests – skiway preparation, inspection and reporting, helicopter sling loading, and the provision of meteorological information to pilots.

Last season at Casey, aircraft ground support staff also contributed to maintenance of the Wilkins-Casey road, delivery of fuel and equipment to and from Wilkins, and the general operation and maintenance of plant.

Next season

As we head into the next Antarctic season, the International Polar Year, and the start of Airlink flights, our challenge will be how to best utilise our aviation personnel and equipment in a rapidly changing operating environment.

Compiled by *AAD Shipping and Air Operations* and the *Air Transport Project*

MEREDITH NATION

An Aircraft Ground Support Officer attaches a sling load to a helicopter, while a C212 waits in the background.

TANIA ASHWORTH

The A319, seen here being inspected by AAD staff in Hobart, is shorter than the A320 (used by Jetstar), and its under-floor cargo space has been commandeered to carry fuel, rather than baggage.

TANIA ASHWORTH

Passengers on the A319's first overflight of Wilkins runway. The aircraft can fly to Wilkins and return to Hobart without refuelling, providing significant safety advantages and reducing the environmental footprint at Wilkins.

*The **Totally Wild** team, Marie Davies (left), Wes Dening and Stephen Harrison with CSIRO's **Scientriffic** editor, Tanya Patrick (right).*

MARIE DAVIES

TOTALLY WILD IN ANTARCTICA

A team from Network Ten's flagship children's series, *Totally Wild*, travelled to Antarctica in 2006 as Australian Antarctic Division Arts Fellows. They filmed six special half hour episodes for *Totally Wild*, an episode of *SCOPE* (Network Ten's children's science series), and a documentary.

Totally Wild has been entertaining and educating children with stories about adventure, wildlife and the environment for more than 15 years. In that time we've only briefly visited Macquarie Island and flown over Antarctica. So we were very excited when told myself (as producer), Wes Dening (reporter) and Stephen Harrison (camera), had been awarded Antarctic Arts Fellowships and would travel to Antarctica in December 2006. In the lead up to the International Polar Year, it was the perfect opportunity to bring Antarctica to *Totally Wild*. We all felt extremely privileged.

It was immediately all systems go. We had a good idea of what stories we wanted to film, but we knew the list would constantly change, adapt and develop. With laptop and ready-made office space, I treated each day of the 12 day voyage on the *Aurora Australis* like a day in the office, with a couple of big exceptions: there were icebergs floating past the 'window' and you had to hold your paperwork and cuppa down so they didn't slide off the table!

But five metre swells and 120 km icebergs weren't going to stop us – we had committed to shooting over 30 stories and a documentary. We had only 12 days to shoot on the Antarctic continent and had to fit in around science projects, a change over at Davis, and a resupply at Casey. When told it takes four times as long to do anything in Antarctica we were under no illusions – this was going to be the most challenging *Totally Wild* shoot to date.

We began by filming stories about pre-departure training, ship safety, icebreakers and the voyage. We wanted our viewers to experience the journey with us, with Wes Dening as their guide.

With the success of the movie *Happy Feet*, penguins were going to be a big drawcard for our young audience. However, along with the wildlife, we wanted to show what it's like to work in such a hostile environment, the important science being done, and to focus on the bigger picture of climate change.

During our whirlwind tour of Davis and Casey we discovered how an ice runway is built, what a LIDAR is, and how and why you collect microscopic organisms from a frozen lake. We also followed a moss sampling expedition into the Vestfold Hills, and got up close to Antarctica's inquisitive wildlife. One of my favourite moments was flying to a Weddell seal colony at 10.30pm. Filming them wallowing around as the 'midnight' sun drifted over the horizon was an experience none of the team will forget.

Let's not forget the wildlife beneath the ice. Underwater photography is challenging at the best of times, but try filming in temperatures of –1.8°C. It took a lot of paperwork and organisation from the team at the Antarctic Division, but I was cleared to snorkel and film when leopard seals were absent. For 45 minutes I filmed cheeky little penguins as they played and caught food all around me. Thanks to my dry suit I was quite toasty for most of the time.

Although we're back in the office now, the journey is far from over. We are reliving our adventures as we edit the stories and put together episodes. The great part is we can 'pause', 'rewind' and 'play' as often as we like.

SCOPE aired their Antarctic episode on 5th March 2007 and *Totally Wild*'s special episodes broadcast for six weeks from 18th May. It was great to see some of our hard work pay off and to share our experiences with our viewers.

It was an honour to represent *Totally Wild* and huge thanks go to the Antarctic Division, our field guide Vonna Keller, the crew of the *Aurora Australis* and all the people who braved the camera to share their lives, work and experiences with us. Without their support we would never have achieved our goals.

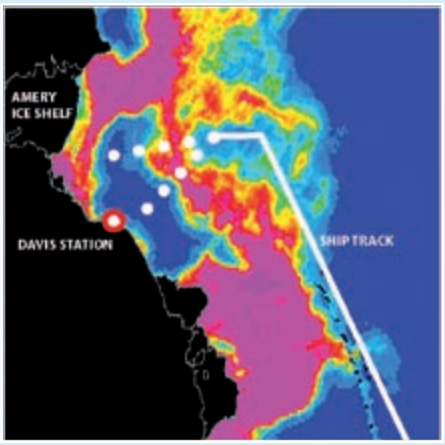
Like previous arts fellows I have grown addicted to all things Antarctic and have just finished reading about Tom Avery's record breaking trek to the South Pole. I probably won't be following in his footsteps, but I will make it back down south one day. For now, I'm content with pressing 'play', 'pause' and 'rewind'.

MARIE DAVIES
Producer 'Totally Wild', Network Ten
AAD Arts Fellow, 2006

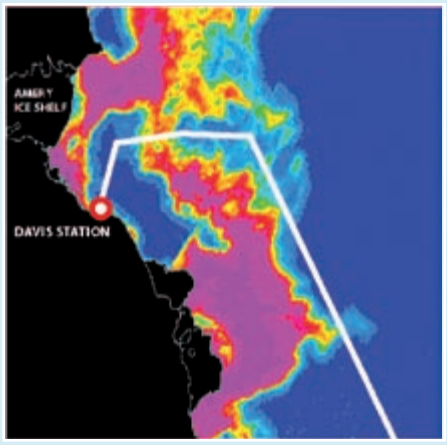
Viewing the poles with PolarView

Polar view amsr.s.comb images of the approaches to Davis station

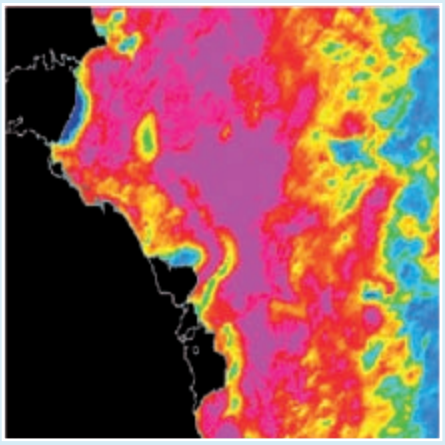
The **amsr.s.comb** product is a satellite passive microwave product, derived from NASA Advanced Microwave Scanning Radiometer/EOS data, with an enhanced pixel size of three kilometres. It shows sea ice concentration, not thickness. The concentration is colour-coded, with pink signifying the highest concentration, followed by reds and yellows, with shades of blue being low concentration.



15 December 2006 *– The* ***Aurora Australis*** *was approaching Davis, avoiding the areas of greatest ice concentration. The ship was nearing a band of higher concentration ice and a decision was required to head directly south or south east. The Voyage Leader consulted with Dr Ian Allison, leader of the Ice, Ocean, Atmosphere and Climate programme of the AAD. Ian had access to the same images and advised that the southern route was likely to be best due to the patterns of expansion and contraction of the ice normally experienced in the area.*



18 December 2006 *– Ian's advice was correct and the ship made it through to the clearer water with minimal delay. Note the differences to the image of only a few days earlier as the sea ice constantly shifts.*



DAVID TONNA/JESSICA FITZPATRICK

01 November 2006 *– This image shows ice conditions much earlier in the season and is an interesting comparison with the conditions encountered by mid season voyages. This image was taken about the time the ship was approaching Mawson and Davis. In these conditions, products like this would be consulted extensively to identify routes of least resistance.*

Safe navigation of sea ice is a uniquely challenging activity that is routinely undertaken in Antarctica by icebreaker ships.

It can be slow and laborious and there is an ever-present risk of besetment in the constantly shifting pack ice surrounding the Antarctic continent. Even without becoming trapped, ships are slowed considerably by sea ice. Avoiding the greatest concentrations of ice can save valuable days, allow scientists to be delivered to Antarctica sooner, and reduce fuel and charter costs.

While the Australian Antarctic Division (AAD) has previously used satellite imagery to assist sea ice navigation, we have recently begun using a new system that enhances our capabilities.

Known as PolarView, it is a product of the European Space Agency. Every day, satellites passing overhead collect radar and passive microwave images of the Antarctic sea ice.

These instruments penetrate the ever-present cloud layer, giving a clear picture of the ice below. Using a number of automatic tools the images are converted into products that graphically illustrate the characteristics of the sea ice on a given day. These products are then distributed to sea ice scientists around the world by e-mail.

Adapting PolarView to support our needs has been a joint venture between the Sea and Air Operations section of the AAD and glaciologists in the Ice, Ocean, Atmosphere and Climate programme, based at the Antarctic Climate and Ecosystems Cooperative Research Centre. The glaciologists developed a browser that can be used to easily view and manipulate the PolarView products.

The process was trialled over three voyages of the RSV *Aurora Australis* in the 2006-07 season. The products were e-mailed directly from Europe to the ship, where the voyage leader could view them on the browser. The voyage leader was then able to assess the ice conditions likely to be encountered, and therefore the best route to be taken. Back in Hobart, a rostered glaciologist received the same products and remained on call to advise the voyage leader on ice assessment, if necessary.

Sea and Air Operations kept the PolarView team appraised of the ship's movement and, at critical points, satellites were tasked to take higher resolution images of key areas coinciding with the approach of the ship.

The trial was a great success. The PolarView products were easy to use with the browser and they accurately reflected the ice conditions encountered. The system enabled the ship to travel more efficiently than would have been previously possible.

We intend to use PolarView again in the International Polar Year, where it should have a significant effect, particularly on an early season sea ice research voyage (page 10). While PolarView does not eliminate the risk of besetment or delay due to ice, it reduces that risk, and is likely to become a standard part of AAD shipping operations.

David Tonna
Sea and Air Operations, AAD

IN BRIEF

New Minister, new name

In the wake of ministerial and portfolio changes in January, the Australian Antarctic Division is now under the stewardship of the Hon Malcolm Turnbull, Minister for the Department of the Environment and Water Resources, and Assistant Minister, the Hon John Cobb.

Australia Day Awards

This year's Australia Day Achievement Medallions were presented to the Australian Antarctic Division team responsible for the development, implementation and management of Assessment Centres – used as part of the selection process for Antarctic expeditioners. The citation reads: *In recognition of the team's significant role in the successful introduction of selection centres for the recruitment of Antarctic expeditioners, which has led to employment of people with much improved personal attributes and a corresponding increase in station harmony, quality of life and work effectiveness in Antarctica.*

AAD

On behalf of the Secretary of the Department of the Environment and Water Resources, Australian Antarctic Division Director Tony Press (second from right), presented Australia Day awards to (from left to right) Noel Backhouse, Jeremy Bonnice and Richard Mulligan. Tina Maher was also part of the winning team.

Antarctica features in *Year Book Australia*

To mark the International Polar Year, the 2007 *Year Book Australia*, released on 24 January, contains a feature article on Antarctica written by the Australian Antarctic Division's Chief Scientist, Professor Michael Stoddart, and Dr Tom Griffiths of the Australian National University.

Dr Griffiths' essay discusses the major phases and trends in the history of Antarctica over two centuries, while Professor Stoddart provides a contemporary picture of life in Antarctica, including a description of what it is like to work in Antarctica and an outline of Australia's programme of scientific research. Shorter articles on specific aspects of Australia's involvement in Antarctica - administration, fishing, tourism, waste management - are contained in relevant chapters of book.

The book is published by the Australian Bureau of Statistics, costs $97, and can be ordered online from www.abs.gov.au or 1300 135 070.

NICKI CHILCOTT

Budget update

This year's budget saw $21.6 million allocated to the Australian Antarctic programme. Of this, the Australian Antarctic Division will receive $20.3 million over four years to cover the cost of rising fuel prices and shipping contract costs, providing some welcome relief to our increasingly stretched operational budget. The Mawson's Huts Foundation will receive $1.3 million to continue the preservation of Mawson's Hut.

Correction

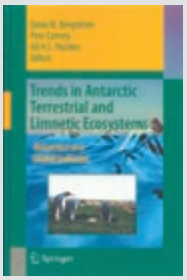
On page 21 of the last issue of the magazine we published a photo purported to be of Ken Assender. The photo was in fact of Viv Hill who was also stationed at Mawson in 1960. Apologies to Viv and to the families and friends of both men.

ROYAL AUSTRALIAN MINT

Polar Series coin

The Royal Australian Mint released the first of four *Polar Series* coins during the launch of the International Polar Year at the Royal Society of Victoria in Melbourne on 1 March. The uncirculated $1 coin features the Australian Antarctic Territory. It precedes three $5 silver proof coins which will be released over the next three years. More information www.ramint.gov.au

Antarctica under threat



Climate change will impose a complex web of threats and interactions on the plants and animals living in the ice-free areas of Antarctica. Increased temperatures may promote growth and reproduction, but may also contribute to drought and associated effects. These scenarios are explored in a new book, *Trends in Antarctic Terrestrial and Limnetic Ecosystems: Antarctica as a Global Indicator*, co-edited by Australian Antarctic Division biologist, Dr Dana Bergstrom. The book is available by contacting Dana.Bergstrom@aad.gov.au.

IGY films online

Thirteen films about the International Geophysical Year of 1957-58 are now online thanks to a team from the University of Colorado and the US National Academy of Sciences. The 29 minute films include: *The Inconstant Air*, which describes studies of the atmosphere and the greenhouse effect; *The Flaming Sky*, which describes research on auroras; and *The Secrets of the Ice*, which describes research on glaciers and ice caps and their role in the Earth system. The films can be downloaded from http://lasp.colorado.edu/igy_nas/

National Oceans Office moves in

Staff of the National Oceans Office, part of the Australian Government's Department of the Environment and Water Resources, moved into new offices constructed at the Australian Antarctic Division in Kingston, on June 18. The National Oceans Office is responsible for implementing Australia's ocean policy.

GLENN JACOBSON

Wollemi planted for World Environment Day

A Wollemi Pine was planted in the Antarctic garden at Kingston to mark World Environment Day on June 5. The planting was presided over by Professor Pat Quilty – the driving force behind the Antarctic garden – and Australian Antarctic Division Deputy Director, Virginia Mudie.

The pine is an appropriate addition to the garden because fossil remains have been discovered throughout Australia, New Zealand and Antarctica – including pollen fossils collected by Professor Quilty in the Prydz Bay region of Antarctica.

Wollemia nobilis belongs to a 200 million-year-old plant family, the *Araucariaceae*, and was thought extinct until bushwalker, David Noble, discovered a stand of them in the Wollemi National Park, near Sydney, in 1994. About 100 trees have since been found in the wild, and thousands have been cloned and sold around the country – the Antarctic Division tree is number 72 000.

VOYAGE TO THE SUB-ANTARCTIC

A five-week marine science voyage to the sub-Antarctic, between January and February this year, investigated a range of ocean properties and processes involved in the cycle of carbon from the atmosphere to the deep ocean. The research, which is critical to understanding the likely impacts of climate change on ocean ecosystems, involved scientists from the Australian Antarctic Division, Antarctic Climate and Ecosystems Cooperative Research Centre, CSIRO Marine and Atmospheric Research and several international institutions. The following articles outline the early results of four research projects conducted during the *Sub-Antarctic Zone Sensitivity to Environmental Change* voyage.

LOOKING TO THE PAST FOR CHANGES IN THE PRESENT

By comparing the fossil record with modern day planktonic species, scientists from the Antarctic Climate and Ecosystems Cooperative Research Centre (ACE CRC) are investigating changes in ocean ecosystems wrought by increasing amounts of anthropogenic (man-made) carbon dioxide.

Since the industrial revolution, increasing amounts of anthropogenic carbon dioxide (CO_2) have been entering the global ocean; changing the carbonate chemistry[1] and pH of the surface ocean and increasing ocean acidity. The ecological effects of changing ocean carbonate chemistry are uncertain, but are thought to include reductions in the ability of some marine organisms, such as coccolithophorids[2], planktonic foraminifera[2], corals and pteropods[3], to form shells. These ecological changes in turn may alter the capacity for the ocean to continue to absorb CO_2 from the atmosphere, and so set up a feedback that could exacerbate the rate and impacts of global greenhouse processes.

Ongoing research by the ACE CRC, comparing foraminifera deposited centuries ago in sediment cores with their living counterparts, seeks to document the effects of ocean acidification on the ability of these organisms to form shells.

The foraminifera have experienced similar geochemical shocks in the past. Reconstructions of surface water carbonate chemistry using shell weights of planktonic foraminifera in deep-sea cores, display changes that have similar timing and magnitude to those inferred from ice cores for atmospheric CO_2 during previous glacial cycles. These past cycles are of similar magnitude to the anthropogenic CO_2 effect.

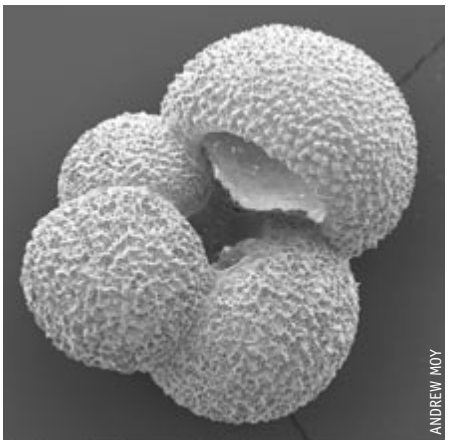
The effects of increased atmospheric CO_2 are already detectable in the carbonate chemistry in the surface ocean. The anthropogenic CO_2 in the Southern Ocean corresponds to a decrease in carbonate ion (CO_3^{2-}) concentration, equivalent to a pH decrease of 0.11 units. This increase in acidity is predicted to cause a change in calcification of the most abundant planktonic foraminifera species in the sub-Antarctic Southern Ocean.

Foraminifera and coccolithophorids secrete shells of calcite, the most stable and robust form of calcium carbonate. Other plankton form shells of aragonite – a mineral phase more vulnerable to the effects of acidification than calcite. In addition to collecting the calcitic foraminifera, we collected samples during the recent *Sub-Antarctic Zone Sensitivity to Environmental Change* voyage, to document the impact of acidification on pteropods – which secrete aragonite shells – over the past few decades. We found pteropods to be surprisingly abundant in the plankton community of the Southern Ocean, both in sub-Antarctic sediment traps and in net tows taken during the voyage.

The Southern Ocean provides an excellent setting for such an analysis because it crosses major surface-ocean gradients in carbonate chemistry and calcium carbonate production, and spans the latitudes of maximum oceanic uptake of CO_2.

The Southern Ocean also contains more CO_2 than other oceans because cooler water absorbs more CO_2 than warmer water. Thus it is a biogeochemical harbinger for the impacts of acidification which may spread throughout the global ocean. The Australasian Sector of the Southern Ocean (south of Australia) is also the site of several long-term studies of ocean chemistry and oceanography, providing substantial background information from which changes can be measured.

By combining data from samples of foraminifera and other calcareous plankton collected from sediment traps, with geological records from seabed cores, we have the potential to detect changes in the carbonate chemistry and the ecologies of calcareous organisms since the industrial revolution, and place them into the context of longer term, pre-industrial dynamics. This 'natural experiment' can only be done with microfossils of existing marine organisms, as they are the same species living in the modern ocean that have experienced the geochemical perturbations of the past 600 000 years.



*The planktonic foraminifera, **Globigerina bulloides**, is being studied for its response to ocean acidification. This specimen was collected in a sub-Antarctic sediment core.*

*This pteropod, **Cavolinia uncinate**, also called a 'wing-footed' pelagic snail, from the Gulf of Alaska, is threatened by ocean acidification. The animal reaches 7-10 mm in length and feeds by secreting large feeding nets or bubbles to which tiny food particles (such as phytoplankton) stick.*

Will Howard and Andrew Moy
ACE CRC

1 When CO_2 dissolves in the ocean it forms carbonic acid (H_2CO_3). Increasing acidity disrupts the formation of calcium carbonate ($CaCO_3$), a major structural component of the shells of several important planktonic organisms.

2 Coccolithophorids and foraminifera are single celled organisms that contribute to the plankton in the ocean. Plankton is composed of phytoplankton – single cell marine plants such as algae – and zooplankton, which includes single and multi-cellular animals (including krill) and other organisms not classed as animals, which eat phytoplankton. The white cliffs of Dover in England, and similar chalk deposits, are made up of the remains of coccolithophorids – a marine alga. Foraminiferans are neither plant nor animal, but belong to a group called 'protists'. They feed on phytoplankton, bacteria and other planktonic organisms.

3 Pteropods are planktonic, snail-like animals (molluscs).

MINICOSMS HELP BUILD A BIGGER PICTURE OF OCEAN ACIDIFICATION

Ocean acidification is a newly recognised threat to marine life caused by increased levels of atmospheric carbon dioxide (CO_2) dissolving in the sea.

The threat is particularly acute in the Southern Ocean because the solubility of CO_2 in sea water increases in cold water. By 2100, concentrations of CO_2 in the Southern Ocean are predicted to increase three-fold, possibly jeopardising the existence of key plankton species[1].

Increased acidity affects the physiology of plankton, the availability of nutrients, and the ability of some species to form calcium carbonate shells. Consequences at the microbial community level are difficult to predict because they involve complex responses of many species in dynamic competition. In an earlier article (*Australian Antarctic Magazine* 10: 26-27), we outlined the scope of the problem. We now have some preliminary results from two major experiments investigating the effects of acidification on microbial communities.

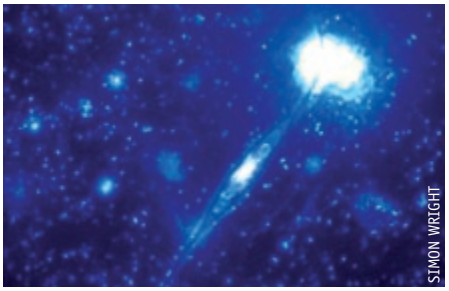
The experiments were conducted during the recent *Sub-Antarctic Zone Sensitivity to Environmental Change* voyage, in ship-board 'minicosm' tanks (which aim to replicate the ecosystem on a small scale). Experiments were performed on microbial communities at two sites: one in the northern sub-Antarctic region (46°19′ S, 140° 40′ E), and one in the polar frontal region (54° 29′ S, 147° 17′ E). The acidity of the minicosms was manipulated to simulate 1, 2, 3 and 4 times current atmospheric concentrations of CO_2 (380 to 1440 ppm). The experiments had three main objectives:

- to determine pH-induced changes in the composition of microbial communities (phytoplankton, protozoa, bacteria, and viruses);
- to quantify pH-induced changes in microbial processes, including rates of production, respiration, grazing, viral infection, CO_2 uptake, oxygen evolution, and calcification;
- to identify species that are 'winners' or 'losers' under conditions of high acidity/CO_2, which can be used as markers of pH-induced changes in the composition of natural communities in the Southern Ocean. Such species will be cultured to determine the physiological traits that cause plankton to be sensitive to or tolerant of high acidity.

The resulting information should allow better predictions of the effect of increased acidity on natural communities of marine microbes in the Southern Ocean.

Complete analysis of the samples and data will take up to a year, but preliminary results showed:

- Phytoplankton photosynthesis removed up to 25% of the CO_2 during the experiment. In the open ocean, this would be quickly replaced from the atmosphere. Due to the reduced buffering capacity of the ocean at elevated CO_2 concentrations, it suggests that phytoplankton production will contribute to future variability of ocean acidification.
- Phytoplankton concentrations were higher in acidified treatments than in controls. Whether this was due to improved phytoplankton growth, or to reduced grazing losses due to the inhibition of protozoa, should become clear after further analysis of the experiments.



*Under ultraviolet light a sample from a minicosm reveals a galaxy of bacteria (small dots) and a larger algal cell (**Cylindrotheca closterium**). The cells were treated with a DNA stain that fluoresces under ultraviolet light.*

Analysis is proceeding on the rates of processes that limit the composition and abundance of microbial communities (photosynthetic fitness, grazing and growth) and mediate atmospheric concentrations of greenhouse gases (photosynthesis, respiration, sinking of organic matter).

We plan to follow up the voyage experiments with further minicosm-based studies of ocean acidification at the Australian Antarctic Division. These will use communities of marine microbes obtained off Tasmania or returned on the *Aurora Australis*, and at an Antarctic continental station during 2008-09.

SIMON WRIGHT and ANDREW DAVIDSON
Environmental Protection and Change programme, AAD and ACE CRC

1 Raven J et al. (2005). Ocean acidification due to increasing atmospheric carbon dioxide. The Royal Society. London 57 pp. Download at www.royalsoc.ac.uk/document.asp?id=3249

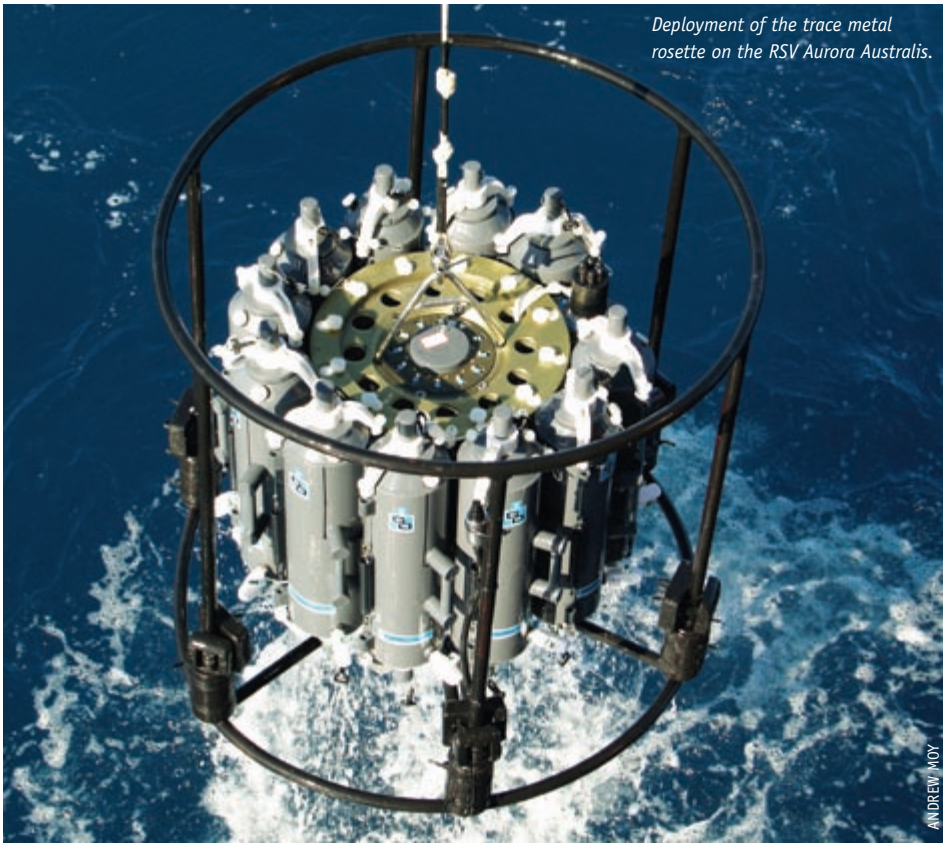
Suellen Cook measures the oxygen concentration of samples from the minicosm tanks and the ocean.

The 650 L gas-tight minicosm tanks use intravenous feeding bags (courtesy of the Polar Medicine Unit) to deliver acid slowly to each tank. Tanks have temperature control, gentle stirring, filtered artificial light, and several sampling points.

Dr Imojen Pearce investigated the grazing activity of protozoa on phytoplankton through a series of dilutions.

Iron and the marine ecosystem

New research suggests that iron plays a key role in controlling primary production (photosynthesis) by phytoplankton in the sub-Antarctic Southern Ocean. But sampling this metal from the deck of a steel ship has its challenges.



Deployment of the trace metal rosette on the RSV Aurora Australis.

ANDREW MOY

Primary production in the ocean is dominated by single-celled microscopic plants called phytoplankton, which convert dissolved carbon dioxide into organic matter within the sunlit portion of the upper ocean. This process forms the basis of the marine ecosystem and exerts an important control on the level of atmospheric carbon dioxide. Vast areas of the open ocean support relatively low phytoplankton production, despite an abundance of the major plant nutrients nitrate and phosphate. The largest of these is the Southern Ocean – a region which has a significant effect on Earth's climate. Over the past decade, marine scientists have discovered that phytoplankton growth in the Southern Ocean is limited by the supply of iron, which is typically present at very low concentrations – about five parts per trillion.

The difficulty in accurately measuring iron at such low levels, and poor knowledge of the distribution and chemical forms of iron in seawater, particularly in the Southern Ocean, are major hurdles to our understanding of the role of iron in regulating primary production. However, during the *Sub-Antarctic Zone Sensitivity to Environmental Change* voyage, we undertook a detailed study of iron distribution, supply (either by wind-blown dust or internally via sediments and currents), chemical form, and availability for phytoplankton growth, in the biogeochemically contrasting sub-Antarctic waters east and west of Tasmania. This research will allow us to infer the role iron may have played in moderating Southern Ocean phytoplankton growth in the past, and its importance for climate change in the future.

Studying iron in seawater is a major challenge that requires specialised sampling and analytical methods. The ubiquitous presence of iron in research vessels, laboratories and many manufactured materials causes a high risk of contamination during sampling, filtration, storage and analysis. Stringent, clean working procedures must be adopted to prevent this, from the initial bottle cleaning through to the final analysis stage.

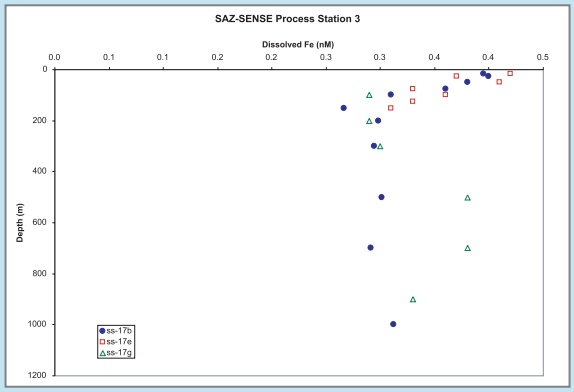
During the voyage we deployed a prototype trace metal sampling rosette (on loan from the New Zealand National Institute for Water and Atmospheric Research). This allowed us, for the first time, to obtain high resolution profiles of iron in the upper 1000 m of the ocean.

The rosette was mostly fabricated from non-metallic materials that would not contaminate samples and was deployed from the trawl deck of the *Aurora Australis* using non-metallic line. A pressure sensor in the rosette triggered each bottle to shut at chosen depths as the bottles were raised to the surface. Large volume 'clean' water samples were also collected for biological incubation and radiotracer experiments. We also made dissolved iron measurements in near real-time at sea, to verify the quality of our sampling techniques during the cruise and identify the best places in which to sample.

This challenging and exacting work provided us with an excellent dataset on our return to Hobart.

Early examination of the dissolved iron dataset indicates that more iron is present in surface waters to the southeast of Tasmania compared to waters to the southwest. This pattern is consistent with that of phytoplankton biomass observed during the voyage by satellite and with the hypothesis that iron has a key role in fuelling primary productivity in this region. Our research also indicates that the iron is supplied internally through filaments of the East Australian Current extending down the east coast of Tasmania, rather than aerosol dust deposition events from the Australian continent. Our studies will now focus on the effect this iron supply has on the productivity of ecosystems of the wider Southern Ocean and how this supply may be influenced by climate change in the future.

ANDREW R. BOWIE,
ACE CRC



A. R. BOWIE

Water column profiles of dissolved iron (Fe) in the sub-Antarctic Southern Ocean to the southeast of Tasmania, showing elevated iron concentrations in surface waters (Bowie et al., unpublished data). Symbols represent different sampling times at the same location.

SHEDDING LIGHT ON CARBON SINKS

Oceanic phytoplankton (microscopic marine plants) are responsible for about 40% of the carbon fixed each year, through photosynthesis, by land and water plants.

Zooplankton (microscopic marine animals) eat phytoplankton and consume between 35% and 70% of the carbon fixed by the phytoplankton. Their faeces and some of the larger phytoplankton sink, providing a natural pathway by which carbon is transferred from the upper ocean into long-term carbon storage, or 'carbon sinks', in the ocean's depths.

We need to be able to find oceanic carbon sinks in order to study their effects on global carbon dioxide levels. Ocean colour satellites, such as the MODIS AQUA and SeaWiFs, help us monitor phytoplankton abundance or biomass by analysing the light reflected by the ocean. The quality of the reflected light is affected by the organisms and organic matter in the upper 50 m of the ocean, and ocean colour satellites can measure these quality differences. By understanding the biology that is responsible for changes in the quality of the light, we can identify regions that are rich in phytoplankton, areas of high primary production, and possible regions where carbon sinks may be occurring.

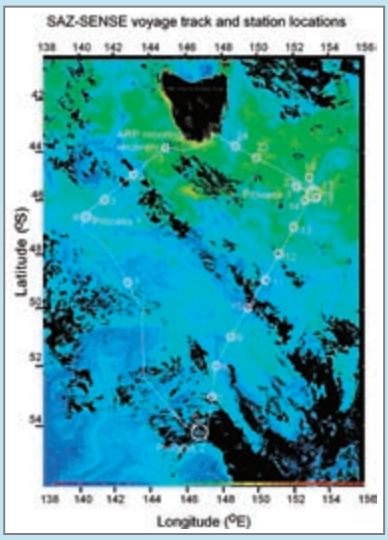
During the *Sub-Antarctic Zone Sensitivity to Environmental Change* voyage we aimed to rigorously compare bio-optical, biomass and primary production measurements made in the water, with satellite ocean colour estimates. Such ship-board measurements are labour intensive and expensive and allow only a small part of the ocean to be sampled. But the measurements enable us to evaluate the accuracy of ocean colour satellite data, which is used to estimate biomass and primary production in the sub-Antarctic and polar regions of the Southern Ocean.

Among the ship-based measurements made during the voyage were the inherent optical properties of the water – the absorption and scattering of light in water. These properties will vary depending on what is in the water, such as phytoplankton, suspended sediments and dissolved and particulate organic matter. We also measured primary production and the biomass of phytoplankton chlorophyll-a (a photosynthetic pigment used as an index of phytoplankton abundance), and examined the phytoplankton species composition using microscopy and pigment analysis. These measurements were compared to ocean colour satellite measurements of inherent optical properties, chlorophyll biomass and primary production.

The data collected during the voyage will be analysed over the coming months and used to improve regional algorithms to convert satellite measurements of light coming from the ocean, into biologically meaningful and useful measurements for the Southern Ocean.

F. Brian Griffiths
CSIRO Marine and Atmospheric Research and ACE CRC

*A WetLabs ac-s underwater spectrophotometer being deployed from the deck of the **Aurora Australis**.*



This ocean colour map shows the distribution of chlorophyll-a during the voyage, with the voyage track superimposed. Chlorophyll is very unevenly distributed in the ocean, with a strong north to south gradient and very low chlorophyll concentrations south of the sub-Antarctic zone, at about 49°S. The complex swirls are due to the underlying physical oceanography and show up warm and cold-core eddies and ocean currents.

Aliens of the ocean – bizarre and beautiful

They look more like aliens than earth-forms, but according to Professor Russ Hopcroft, the thousands of microscopic marine animals that make up the 'zooplankton' in our oceans, are a critical part of the marine ecosystem, a sensitive indicator of climate change, and a great photographic subject.

Professor Hopcroft is paying a six-month visit to the Australian Antarctic Division as part of a year-long sabbatical from the University of Alaska in Fairbanks, and to strengthen ties with Australian researchers involved in the Census of Antarctic Marine Life – a major Australian-led project of the International Polar Year, which aims to determine the biodiversity, abundance and distribution of marine species around Antarctica.

Professor Hopcroft co-leads a sister project of the Antarctic census – Arctic Ocean Diversity – which will create an inventory of biodiversity in the Arctic sea ice, water column and sea floor, from the shallow shelves to the deep basins.

Professor Hopcroft's area of expertise is zooplankton ecology; a profession which has seen him cruising the North Pacific Ocean, Bering Sea, Arctic Ocean, Sargasso Sea and the Caribbean, among others, for samples of his tiny subjects. Many of the organisms he studies in the Arctic are also found around the Antarctic, or are closely related, but there are others he is yet to meet.

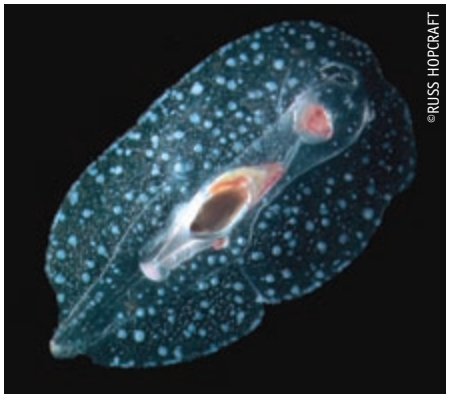
'I'm really hoping to get familiar with the animals here and to do some photography,' he said.

Professor Hopcroft started taking photographs of zooplankton four years ago, because of a lack of good quality, publicly accessible photos that showcased the animals' both bizarre and beautiful characteristics.

'It's really hard to get students interested in working with dead, pickled animals that have no colour, behaviour or movement and that are often twisted into unnatural poses,' he observed.

He has since amassed a portfolio of thousands – many of which have appeared in journals, on web sites and in public relations material. All his photos are taken under a light microscope using live animals, which range in size from millimetres to about five centimetres.

*This amphipod, **Phronema**, is sticking its head of its house – the hollowed out living body of a salp – where it will eventually lay its eggs and raise its family. You thought the movie **Alien** was a wild idea, see any resemblance? These mini crustaceans reach sizes of up to 2 cm.*



*This heteropod, **Pterosoma planum**, (a group of predatory pelagic snails) has a thin shell and a mouth with hooked teeth (towards top right of photo). It grows up to 5 cm in size.*

'What's really surprised me is that I've received more public interest and recognition of my work from my photographs, than from my science,' he said.

'The photos have really added value to the work I do and help educate people about the importance of these organisms, and a part of the ecosystem that people know so little about.'

Snail-like 'pteropods'* are one group of animals Professor Hopcroft has become good at identifying through his photography. They are also one species more vulnerable to ocean acidification, which is occurring as a consequence of climate change.

Pteropods make shells out of calcium carbonate. However, their ability to form these shells correctly is affected as increasing amounts of atmospheric carbon dioxide dissolves in the ocean, making it more acidic and changing the chemical form of the calcium carbonate available. As zooplankton and other planktonic (drifting) organisms, such as algae, form the base of the food chain, changes in the structure of the planktonic ecosystem will have impacts all the way up the food chain to the fish, penguins, seals and whales.

'It is critical we study the ecosystem over the longer term, to see how climate change is impacting on the zooplankton and other planktonic organisms,' Professor Hopcroft said.

Professor Hopcroft spent the first six months of his sabbatical at the Australian Institute of Marine Science in Townsville. He and his young family enjoyed meeting some of Australia's more charismatic fauna, including wallabies, echidnas, snakes and parrots – quite a change from the moose, bears, Arctic foxes and beavers of his home town, and the alien-like microfauna that consume his working hours.

Wendy Pyper
Information Services, AAD

* Two of Professor Hopcroft's pteropod images are featured on page 24 and in Freeze Frame on page 37.

MARINE MAMMAL SCIENCE

The Australian Centre for Applied Marine Mammal Science, established at the Australian Antarctic Division (AAD) last year, is Australia's first major national research centre focused on understanding, protecting and conserving whales, dolphins, seals and dugongs. This national focus brings together mammals from tropical, temperate and Antarctic waters – an unusual mix for an Antarctic organisation, but critical to the AAD's broader research and advisory role within the Department of the Environment and Water Resources. Of the 15 projects funded in the Centre's first year, four involve dugongs, two involve sea lions and nine involve whales. The following three articles provide a snapshot of the projects being undertaken through the centre.

In the future, the ability to age tooth samples from the Indo-Pacific bottlenose dolphin (pictured) could provide vital information on the life history of the species, which is potentially threatened by increasing human activity in its inshore habitat.

Marine mammal research comes of age

To fully understand the biology and ecology of marine mammal populations and the impacts of humans on species, scientists need to know the age of individuals in a population.

Armed with this knowledge, we can determine rates of marine mammal growth, reproduction and mortality, age at sexual maturity, and how these may vary between populations. The ability to assess age-related aspects of marine mammal populations also allows us to determine the reaction of a population to environmental stresses – both natural and human-induced.

Teeth make good candidates for age estimation in marine mammals because layers are laid down in the dentine or cementum as the animals get older, much like the growth rings in trees. With the proper techniques these layers can be counted. Teeth have been used to derive age estimates in a large number of marine mammal species for over 50 years. However, little information is available for Australian marine mammals as there is limited experience in aging techniques in Australia. Australian researchers have had to either pay for samples to be aged by overseas laboratories, or travel overseas for training.

Now the South Australian Museum, in collaboration with researchers from the University of Tasmania, the University of Alaska and La Trobe University, have received $42 000 from the new Australian Centre for Applied Marine Mammal Science, to help set up a centre of excellence for aging marine mammals.

The centre will greatly enhance the output of many Australian research projects studying threatened and poorly known species, such as the Australian sea lion, sperm whale, snubfin dolphin, Indo-Pacific humpback dolphin and spinner dolphin. Money for the initiative will also fund a workshop in August 2007, to train a collaborative network of researchers in tooth aging and produce a technical manual on tooth aging and structure.

The South Australian Museum houses the largest and most comprehensive marine mammal collection in Australia and has been actively involved in marine mammal research for many years, making it an ideal candidate to house a tooth aging research centre. Research through the centre will greatly enhance the management and conservation of marine mammal species. It is hoped that support for this national aging facility will be sustained, enabling critical research into the biology and ecology of Australian marine mammals now and into the future.

For further information on the workshop contact Catherine Kemper at Kemper.Cath@saugov.sa.gov.au

CATHERINE KEMPER and KAREN EVANS
South Australian Museum and University of Tasmania

The South Australian Museum's collection of whales and dolphins numbers in excess of 900 specimens and includes 35 species.

A sectioned sperm whale tooth showing growth layer groups. From ***Journal of Cetacean Research and Management*** *(2002) 4(2):193-202.*

RICHARD CAMPBELL

Australian sea lions and humans share a taste for some sea food species, such as rock lobsters. INSET: This juvenile Australian sea lion was snapped by a 'pot-cam', diving into the rock lobster pot. New measures have been introduced recently in commercial and recreational fisheries, to prevent the accidental drowning of pup and juvenile sea lions in these pots.

FEEDING HABITS PROVIDE CLUES TO SEA LION THREATS

Australian sea lions, *Neophoca cinerea*, were recently added to the Federal threatened species list because of concerns over the current population status (about 11 200) and the threat of continued population declines. But what is threatening the future of our only endemic sea lion species?

A recent threat analysis highlighted the potential impact of incidental mortality of sea lions in demersal (bottom) set gillnet operations. Consequently, the Western Australian Department of Fisheries, through the new Australian Centre for Applied Marine Mammal Science (ACAMMS), will investigate the overlap between demersal gillnet fisheries and the foraging range of Australian sea lions, to better understand and, if necessary, mitigate this threat.

Australian sea lions inhabit the continental shelf environments of the southern and south-western coasts of Australia, from The Pages near Kangaroo Island in South Australia, around to the Houtman Abrolhos Islands in Western Australia. They are predominantly benthic (sea floor) feeders, diving to the sea bottom looking for a wide variety of food, including commercial species, such as rock lobsters and octopus, to cuttlefish and sting rays. They forage across the continental shelf for days at a time, covering over 200 km on a round trip. This brings them into contact with human activities, including commercial fisheries, where they may make an easy meal of fish caught in nets or lobsters caught in a pot. Occasionally, however, they become trapped in the fishing gear and drown. Just how often this occurs, and the consequence of these incidental mortalities, is not known.

DIMITRIOS CHRISTANOPOULOS

A juvenile Australian sea lion fitted with a satellite tracking instrument, time-depth recorder and VHF tag. Data from these instruments will help scientists understand more about the animals' foraging behaviour and range.

Recently, commercial and recreational lobster fishers in Western Australia have, in some areas, been required to fit exclusion devices to rock lobster pots to stop small sea lions becoming trapped and drowning. This has been achieved through years of consultation and hard work by the commercial fishery and the Western Australian Department of Fisheries.

The Department now hopes to gain a better understanding of the interaction between sea lions and the demersal set gillnet fisheries, which target many species of shark and finfish for both domestic and international markets. Because sea lions spend so much of their time at sea actually on the sea floor, there is a good chance they will come into contact with this commercial fishery.

The new ACAMMS project will investigate the foraging behaviour and range of pup, juvenile and adult female sea lions in Western Australia, using the latest satellite tag and micro-processor technologies. This will involve capturing animals to deploy the tags and returning a few weeks later to recapture the animals and retrieve the data. From this information we will build up a picture of the foraging range of these various sized sea lions and construct a relatively simple model that predicts the foraging range of the entire population.

Whilst foraging studies have been conducted on this species in some populations, there is a great deal of variation in their behaviour from location to location. So we aim to obtain accurate information from as many sites as possible.

Shark fishing boats have their own kind of onboard tag – a Vessel Monitoring System or VMS. This accurately tracks the fishing effort and is complemented by a new daily logbook system that provides detailed information about the catch.

Putting these resources together will allow us to derive a map showing where the overlap between fishing effort and sea lion foraging effort is occurring. Together with information on the status of sea lion populations in the various areas, we will identify where the greatest threat posed by incidental capture in the fishing gear exists.

This knowledge can be used to investigate different scenarios about how to mitigate the capture of sea lions in gillnet fisheries. For example, a refined system of temporal and/or spatial closures could be designed that will have minimal disturbance on fishing activities and catches.

Other benefits of this project include gaining essential knowledge about the foraging habitats for this species. A greater understanding of their biology will also help determine how all the different users in the marine environment fit together. This kind of information is the cornerstone of managing marine ecosystems and in implementing ecosystem-based fishery management, which aims to ensure a sustainable future for all marine species.

Richard Campbell
Western Australian Department of Fisheries

TRACKING GIANTS OF THE DEEP

When you find yourself 40 nautical miles out to sea in a six-metre zodiac, and about to voluntarily position yourself within metres of a surfacing blue whale - the largest animal on Earth - a number of questions spring to mind, not the least of which is *'what are we doing here?!'*. Let me explain.

Every year great whales, such as blue and humpback whales, migrate south during spring to their summer feeding grounds in the cold waters of Antarctica, and north in autumn, to their warm-water breeding grounds. However, while some locations along the Australian coast are well known rest areas for migrating whales, the medium and large scale movements of these animals remain largely unknown.

Baleen whales are important consumers of marine resources, and come under a high level of management and research attention. Knowledge of their medium to large scale movements is fundamental to informed debate on the diverse manner in which humans interact with whales. So, *what are we doing here?*

We are trying to answer some basic questions: Where do these whales go to feed and breed? What routes do they take on their migrations? Do animals from different populations intermingle when feeding in Antarctic waters?

Unfortunately, it can be difficult to answer these seemingly simple questions. Whales live most of their lives in remote regions of oceans and coastlines and they are often shy and elusive. Species such as blue and humpback whales travel thousands of kilometres a year, and their summer ranges take them well into Antarctic waters. To get answers to our questions, we need a way of tracking whales' movements remotely over time.

A deployed satellite tag (antenna visible within circle) on a humpback whale.


MICHELLE JENNER

Through the new Australian Centre for Applied Marine Mammal Science, a team of researchers from the Australian Antarctic Division (AAD) is developing a whale tag which, once attached, transmits location information to satellites orbiting the Earth. Studies of at-sea movements of whales have been limited, due to the difficulty of reliably attaching satellite tags. Because of a whale's size, tracking devices must be attached to the animals as they swim. The tags used in most studies of large-scale cetacean movements tend to be long and are implanted under the skin, effectively anchored in the muscle layer.

The AAD team is designing smaller tags for satellite telemetry work, which will be implanted only into the blubber of whales. Blubber contains very few blood vessels or nerves, so using small tags, which can hold well in the blubber, reduces the invasiveness of telemetry work.

The team has recently returned from deploying the latest prototype tags on blue whales in Western Australia, in collaboration with the Centre for Whale Research. The centre's large power vessel, RV *Whalesong II*, is used as a mothership and sighting platform, while their six-metre, rigid-hulled, semi-inflatable zodiac is used for the tagging work.

The tags comprise the latest miniaturised transmitting electronics available, with minimum battery power to achieve the tracking duration. The electronics and battery are encased in epoxy and high grade stainless steel and/or titanium components, which are almost completely inert in body tissues. The tag has been developed jointly by the AAD and Sirtrack Ltd, New Zealand and its design continues to improve with testing.

The satellite tags are deployed via a modified pneumatic line-thrower from the zodiac, 3-15 m from the whale. The tag penetrates the whale's skin and blubber and sometimes the dense connective tissue layer that encases the muscle mass. A flexible transmitting aerial extends about 17 cm from the top of the tag. The positioning of the tag is species specific, but aims to give the aerial maximum time out of the water, each time the animal surfaces. This is generally close to the whale's dorsal midline, between the dorsal and pectoral fins.

The tag transmits a signal to the Argos satellite system for weeks to months. Because of the superficial application of the tag, it will eventually be rejected from the blubber, much like a splinter, and fall out.

The data we hope to collect is of strategic importance in the management of human-whale interactions and threatening processes, and particularly to the economically significant whale watching and petroleum industries. As whale numbers continue to increase, interactions with ships, in major shipping channels, will increase. The information is of particular relevance for the conservation of threatened species, such as the southern right whale and blue whale, and to international forums such as the International Whaling Commission.

SARAH ROBINSON
Southern Ocean Ecosystems programme, AAD


MIKE DOUBLE

The whale tagging team approaches a whale in their zodiac.

FAUNA FLOURISH UNDER

Scientists taking part in the Amery Ice Shelf Ocean Research (AMISOR) project were surprised recently by the discovery of rich and diverse marine life deep beneath the ice shelf.

Video cameras lowered into three (of four) boreholes, drilled across the 550 km-long ice shelf to depths of 750-1300 m below sea level, revealed flourishing life forms existing some 100-250 km distant from the open ocean.

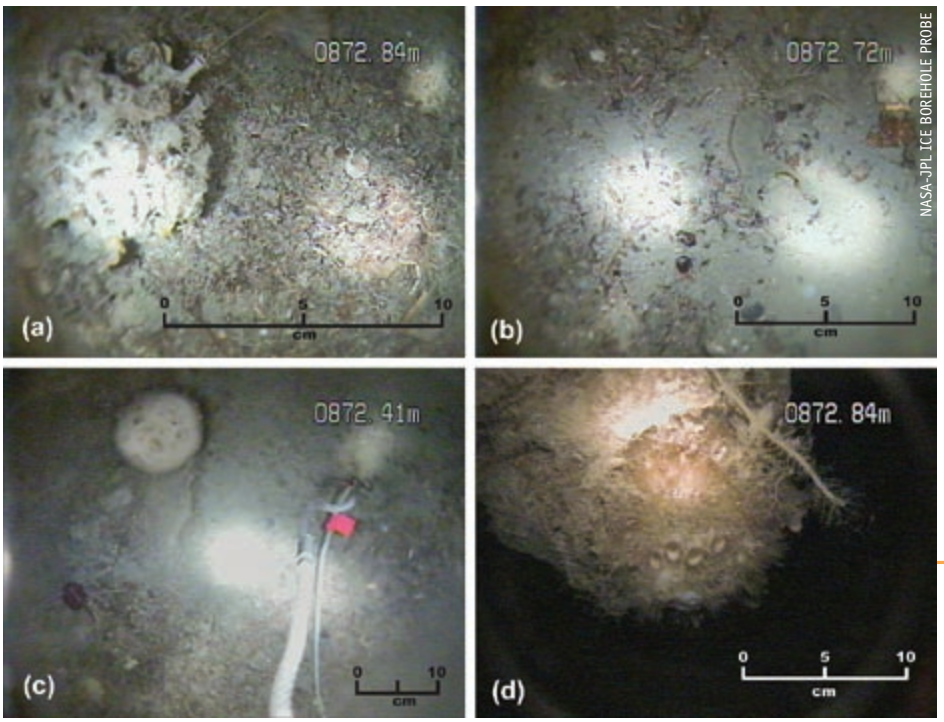
Initially the blackness was punctuated by swarms of tiny particles being carried along in the currents beneath the shelf. However, an attentive eye soon realised that a small percentage of these were actually moving haphazardly across the field of view, often against the current. Biologists were quick to recognise the presence of amphipods (tiny mobile crustaceans) in the water column.

Evidently a suitable percentage of the current-swept particle swarm was edible detritus, rather than merely crushed rock debris, ground from the bedrock of Antarctica by the ice sheet.

The next sighting was a major surprise: a krill auditioned for the camera with a looping dance in the spotlights at a depth of some 750 m beneath the drill site at AM01 (see map). This was most likely an 'ice krill' (*Euphausia crystallophorias*), and it was the first report of these lively crustaceans at such great depth. We have since witnessed them beneath the shelf at AM03 and AM04, which are both deeper and further from open water.

The sea floor at AM01 was also home to a complex benthic (sea floor) assemblage, dominated by suspension-feeding invertebrates including sponges, molluscs, sea urchins and sea fans, unlike anything previously reported so far beneath an ice shelf (see figure).

Global climate change studies focus attention on the seabed under ice shelves, or in areas previously covered by them (such as parts of the Larsen Ice Shelf – see story page 6), for evidence of prior ice shelf advance or retreat preserved as fossils in seabed sediments. The AMISOR findings are important because the community beneath AM01 is indistinguishable from that commonly found on the Antarctic continental shelf in open water. Before now, if palaeontologists had found the fossil remains of such a complex community of organisms, they would probably assume that the site was free of the ice shelf when these



The seabed at AM01 contained a richly diverse benthic community with: (a) – bryozoan species (large structure at left) and calcareous tubes; (b) – mucous net filter feeders (right of centre); (c) – white sponge (top left) and urchin (lower left); and (d) – sponge (centre) and hyoids (top right).


MIKE CRAVEN

The AMISOR hot water drill camp.

HONEYCOMB ICE

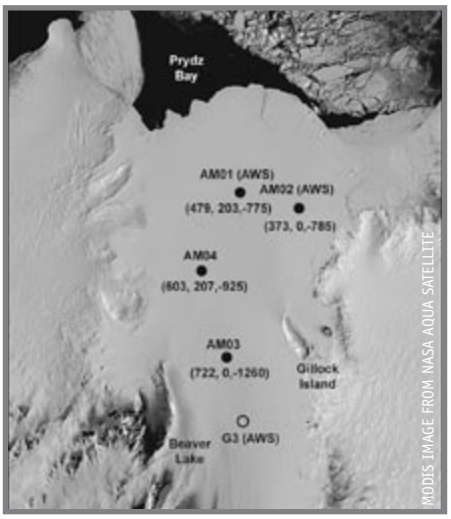
animals were living there. Although a reasonable assumption, it turns out to be incorrect. Thus, these new observations provide a better context for sediment core interpretation of the history of the ice shelf in the region.

Seabed borehole video and sediment core samples were recently obtained from beneath AM03 and AM04. At first glance there appears to be less species diversity and abundance than below AM01, but investigations are continuing. It is exciting that these sites, with increasing distance from open water, could provide insight to the colonisation processes in such extreme environments.

Another intriguing discovery of the AMISOR project has been the porous nature of the marine ice toward the base of the ice shelf at sites AM01 and AM04. This feature manifested itself during the drilling process when a pressure sensor in the well indicated that hydraulic connection with the ocean cavity had been achieved whilst the drill head was still many tens of metres above the true base of the shelf.

Borehole video footage showed that the lower 70-100 m of the marine ice was honeycomb in nature with ice platelets (large ice crystals) welded together, and interstitial sea water filling progressively larger and larger cavities. The ability of sea water to move relatively freely through this honeycomb ice makes these parts of the shelf vulnerable to any increases in sea water temperatures.

The next phase of the AMISOR project is likely to focus on the uniqueness of the honeycomb nature of the marine ice, and its susceptibility to temperature and ocean circulation pattern changes beneath the shelf. We will also examine the gradation of benthic communities as we progress further beneath the shelf.



Location map showing the four borehole sites and the automatic weather station at G3. The distance between AM01 and AM02 is approximately 50 km. Numbers in parenthesis beneath each site are total ice thickness, marine ice thickness, and depth of sea floor below mean sea level.

To complete the story that the Amery Ice Shelf and environs have to tell us though, we need to launch other major deep field projects, for example, a full seismic survey for the true bathymetry (depth) of the southern half of the shelf. Ultimately, we hope to unleash a fully instrumented autonomous underwater vehicle to roam the depths of the ocean cavity and unlock more of its fascinating secrets.

Mike Craven[1], Ian Allison[1] and Martin Riddle[2]

1 *Ice, Ocean, Atmosphere and Climate programme, AAD and ACE CRC*

2 *Environmental Protection and Change programme, AAD*

What is AMISOR?

The Amery Ice Shelf Ocean Research (AMISOR) project is part of a broad umbrella study of the entire Lambert Glacier Basin, Amery Ice Shelf system (located between Mawson and Davis in East Antarctica), to understand both the climatic history of the region, and its probable response to global warming.

The project is part of the Australian Antarctic Division's Ice, Ocean, Atmosphere and Climate programme and the Sea Level Rise programme within the Antarctic Climate and Ecosystems Cooperative Research Centre.

The project, which has been running since 2000, brings together glaciological and seismological fieldwork, marine science and oceanographic surveys, sedimentation history and sea floor biology, airborne and satellite remote sensing, and numerical modelling of the past and future behaviour of the ice-ocean system.

The central pillar of AMISOR has been fieldwork involving hot water drilling of four boreholes through the ice shelf. Closely linked with this, and often working in tandem in the field, have been two other projects: a systematic seismic survey of the north-central shelf region (run by Macquarie University); and monitoring of the 'Loose Tooth' – a series of developing rifts at the front of the shelf that will lead to an iceberg calving event (run by the University of Tasmania and the Scripps Institution of Oceanography in California). These activities feed data into 'coupled' ice shelf-ocean models that predict the patterns of melting and freezing at the base of the shelf, the modifications to water masses circulating below the shelf, and examine the way iceberg-forming rifts propagate into the body of the shelf.

Measurements and sampling activities at the borehole sites have provided information on such things as ice shelf elevation, ice thickness, surface weather, ice shelf temperature profiles, and annual variability in salinity and temperature in the water cavity below the ice shelf.

Thirty metres under the sea ice

Divers from the Australian Antarctic Divison's (AAD) Environmental Protection and Change programme ventured into the seldom visited but fascinating under-ice marine environment off Casey last summer. The team supported a variety of national and international research projects investigating the biodiversity of nearshore Antarctic marine ecosystems, and the effects of human activity on these systems at local and global scales.


MARTIN RIDDLE

A rich diversity of life exists under the sea ice, including these feather duster worms, sea urchins, sponges and a starfish.

Research diving under Antarctic sea ice represents the culmination of a lot of personal preparation and team endeavour. Each diver undergoes pre-trip familiarisation training and dive medicals, in addition to the normal pre-trip medicals and training. Equipment is tested, checked and re-checked at Kingston, and once again when we arrive on station.

Not long after our arrival at Casey, a drilling team was out on the sea ice surveying access routes and digging holes through the 1.3-2 m thick sea ice. More than 80 holes (90 cm diameter) were drilled through the sea ice, both for divers and to deploy equipment and instruments, such as sediment traps and oxygen probes.


JONNY STARK

Tenders assist divers into the dive hole.

Safety is paramount and each diver undergoes multiple checks as their 'tender' assists them into their dry suit and dive harness, and helps them shuffle to the dive hole. Once in the water you are released from the awkwardness and the pull of the massive weights needed to counteract the dry suit buoyancy, and can float freely and comfortably in the -1.85°C waters. After descending 1-2 m through an icy, water filled tunnel, you enter one of the worlds most rarely visited and spectacular environments.

At first it's very dark. The sea ice filters out a lot of sunlight, initially creating a mysterious, eerie gloom. Your eyes adjust quickly, however, revealing a brightly coloured world as you descend to depths of up to 30 m. Red, green, yellow and orange sponges, crimson sea urchins, pink and orange sea anemones, white fan worms, colourful sea stars and red, green and brown algae can cover any rocky surface. Sea-mice (burrowing urchins) and giant worms, metres long, crawl through the muddy sediments. The water itself is amongst the clearest in the world, and even with the low light levels, visibility of 50 m or more is common. Looking upwards provides a vivid reminder of where you are. Pools of trapped air move about like puddles of mercury on the thick icy roof and sunlight streams through the dive holes, sending brilliant columns of light to the sea floor below.

Apart from marvelling at the sights there is a lot of hard work to be done.

In the flurry of diving activity last summer, a wide variety of samples were collected during 188 person dives (more than 132 hours underwater) over eight weeks. Cores of sediment collected from the sea floor continued the AAD's long-term biological monitoring of the Thala Valley clean-up, as well as providing Malaysian and Tasmanian scientists with diatoms for their work on the community composition and molecular ecology of these single celled marine algae. Other AAD work included collecting a variety of marine organisms for a new study of nearshore marine food webs, and a study of how depth affects communities of invertebrates living on the sea floor.

We also retrieved a long-term experiment investigating the effects of hydrocarbons (such as Special Antarctic Blend diesel) on marine communities. Trays of sediment, some treated with hydrocarbons and some untreated, were left sitting on the sea floor for up to five years, to allow invertebrates to colonise and establish communities. Differences among these communities will indicate how spills of petroleum products may affect nearshore marine communities in Antarctica, how long the oils may persist, and how long recovery will take.

Continuing another long running project, Dr John Runcie of the University of Sydney, conducted fine scale measurements of the photosynthetic activity of various species of macroalgae and diatoms on the sea floor and the underside of the sea ice. Decreased photosynthetic activity in these marine plants in the bays close to Casey may indicate stress caused by contaminants entering the nearshore marine ecosystem. University of New South Wales PhD students, Nicole Hill and Graeme Clarke, continued research, begun in 2005-06, on communities of marine invertebrates living on small boulders, recruitment tiles and sediment trays. Characterisation of the invertebrate fauna and flora of the nearshore region of Casey, from a variety of Australian Antarctic science projects, will add to our knowledge of the biodiversity of nearshore marine habitats in Eastern Antarctica, ultimately aiding our efforts to protect this environment and manage our impacts.

Glenn Johnstone and Jonny Stark
Environmental Protection and Change programme, AAD

These grey-headed albatrosses at South Georgia are one of the species that has benefited from actions taken by CCAMLR to protect Southern Ocean seabirds.

GRAHAM ROBERTSON

GOOD NEWS FOR SOUTHERN OCEAN SEABIRDS

Over the last 15 years large numbers of seabirds have been killed by longline and trawl fishing vessels operating throughout the southern hemisphere.

Some of the worst fatalities have occurred in longline fisheries for Patagonian toothfish which concentrates around many of the sub-Antarctic islands where seabirds assemble to breed. Some seabird populations have been ravaged, none more so than albatrosses at South Georgia which have decreased by 30% in the last 20 years. The impact is alarming – in 1997, shortly after the commencement of systematic data collection by the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR), nearly 6000 seabirds were killed in the legal fishery at South Georgia alone. White-chinned petrels in the Indian Ocean sector have fared just as badly: since 2002 about 40 000 white-chins have been killed on longlines in the Kerguelen and Crozet toothfish fisheries.

In spite of these scenarios, not all news about the impact of fisheries on seabirds is bad and once in a while something really good happens. At its 2006 meeting, CCAMLR reported that only two seabirds were killed by legal toothfish longliners in CCAMLR regulated waters. This estimate excludes the Kerguelen region where mortality, though reduced, remains high despite continuing efforts, but includes all other toothfish longlining in CCAMLR. The low number of fatalities is a remarkable achievement, especially in light of the fishing effort in 2006 when nearly 33 million hooks were set for toothfish.

Given the magnitude of the previous mortality, the size of the hooking effort and the difficulty in changing entrenched fishing practices, how has it been possible for CCAMLR to reduce seabird mortality to such a low level over such a vast area of the world's oceans? In its 25-year history CCAMLR has matured into the most effective regional fisheries management organisation in the world in the achievement of ecologically sustainable fishing practices. Key to CCAMLR's success is the numerous specialist working groups and the breadth of issues they cover, a plethora of conservation measures designed to protect all components of the marine environment, the presence of scientific observers on all longline vessels and, most critically, the development of the political willingness to enact seasonal fishery closures if deemed necessary for conservation. The strategic closure of the South Georgia fishery in summer (when seabirds are breeding) in the early 2000s, and gradual improvement in compliance with conservation measures by longline operators in CCAMLR waters in general, were responsible for achieving the low seabird mortality in 2006.

The credit for this success is due to the 24 member states that constitute CCAMLR, especially people in the Incidental Mortality Associated with Fishing and the Fish Stock Assessment working groups. These working groups are responsible for the initiatives that ultimately shape seabird conservation outcomes, and include people responsible for carrying proposals forward to the Scientific Committee, and then to the Commission which is the decision-making forum of CCAMLR. Many working group members have attended the month-long CCAMLR meeting (held annually in Hobart) for years, working tirelessly through the negotiations that are commonplace in the multi-national approach to fisheries management, to achieve fisheries with a low impact on seabirds and other aspects of the marine environment.

While there is much work to be done to improve the situation in the Kerguelen fishery and to conserve South Georgia albatrosses, which continue to decrease due to mortality in fisheries to the north of the CCAMLR region, the 2006 statistics for CCAMLR waters provide optimism that further efforts will ensure improved conservation of these iconic sea birds.

Graham Robertson,
Southern Ocean Ecosystems programme

PLUMBING ON ICE

Jason Ahrens spoke to Annie Rushton about his experiences as a plumber in Antarctica.


BARRY BALKIN

I have been interested in Antarctica since high school, but it took nearly 30 years to get here. I am one of two wintering plumbers at Davis, and the Building Services Supervisor for 2007. I gained my ticket as a plumber and gas fitter, and went on to do mechanical services a few years later. Most recently, I worked in the domestic market in Victoria.

A major summer plumbing job here at Davis is to make a year's supply of potable water – over a million litres. Davis obtains its water by reverse osmosis from a small tarn, which entails about three hours of work every day. The job has been an eye-opener, as few plumbers have worked with reverse osmosis plants back home. In fact, it is the challenges of working in Antarctica that really appeal to me.

Unlike in Australia, you can't just go out and buy spare parts, and because of the environment, everything takes ten times as long. You need to consider alternatives and improvise. This is one of the great attractions for me, as you have to think laterally, and we all help each other in a way that rarely happens at home. Electricians assist us and we help carpenters and vice versa. The same trend applies to station life generally. During resupply for example, everyone downs tools and helps. I drove machinery, moved containers and worked as beach master, liaising between ship and shore. We also take turns to do kitchen slushy duties and general station cleaning.

I am also the Deputy Station Leader, and take responsibility for the station when our Station Leader is absent. Both he and I are invested with legal Special Constable powers, and are designated as Antarctic Treaty Inspectors, which means we monitor project permits.


JASON AHRENS

Other trades-related jobs include maintaining the 'heart and lungs' of the station – the ventilation and heating systems – in particular the heating hot water circulation to all buildings. We also ensure that the sewage system functions effectively and manage waste management operations, including incineration of burnables in high temperature incinerators. We record waste categories and quantities as part of the Australian Antarctic Division's (AAD) environmental management system.

As the wintering Building Services Supervisor, I supervise the carpenter, two electricians, another plumber and a trades' assistant. This winter our work will focus on the internal fit-out of the new summer accommodation module, in preparation for next season.

We keep food frozen and maintain station gas supplies, including kitchen cooking facilities and medical gases. We test the medical gases each month with the doctor, to ensure that the regulators and alarm systems are functional.

Working with medical gases was quite new to me, but the AAD organised training for me. In fact, I undertook extensive training, including in backflow prevention and maintaining oil fired boilers (not commonly used in Australia). I also gained an articulated loader ticket and forklift licence, did the specialised Breathing Apparatus fire training, and am in the Davis first response team for search and rescue.

Towards the end of summer, I assisted a scientific programme on the Lambert Glacier to return their equipment to station by helicopter. It was a fantastic experience just to fly down. We flew over the glacier and Progress and Zhong Shan, the Russian and Chinese stations.

Living in a close community is very different to being at home. Without a doubt, the most important attribute here is tolerance; we live and work together and you have to be diplomatic.

A key feature of life in Antarctica is that we are all keen to be here, and prepared to work together to get things done. Although there are always different challenges, you get all the support you need from your mates, the station leader, and staff at Kingston. You don't have to do anything alone, and that is very special.

*This pteropod or pelagic snail, **Limacina helicina**, was collected from the Gulf of Alaska and photographed through a light microscope. I photograph them live in order to capture their natural movement and behaviour, so it can take a while to get a good shot. I usually take 100 to 200 photos a day, mostly of zooplankton, which I fit in around my usual work. They help me better educate and inspire my students and raise public awareness of an important and beautiful part of the ecosystem that's now under threat from climate change.*

FREEZE FRAME

Professor Russ Hopcroft is a zooplankton ecologist and principal investigator for the Census of Marine Life Arctic Ocean Diversity project, based at the University of Alaska, Fairbanks. He spent six months at the Australian Antarctic Division strengthening ties with his Census of Antarctic Marine Life counterparts.

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