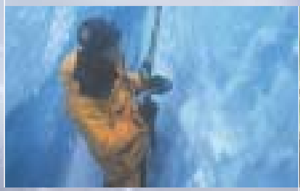

Atmospheric physics

Sustainable harvesting

Oceanographic research

Global climate change

Biodiversity

SOUTHERLY PROSPECTS: ANTARCTIC SCIENCE MEETS NEW CHALLENGES

Australian ANTARCTIC MAGAZINE

Autumn 2001

1

AAD Photo

Dear Readers

As Minister for the Environment and Heritage, I have the privilege of having the Australian Antarctic Program within my portfolio responsibilities.

Two visits to Antarctica have instilled in me lasting impressions of the magnitude and grandeur of the Antarctic wilderness. And admiration of the people who choose to work there. I have seen at first hand the difficulties of living and working in Antarctica, and appreciate the great opportunities provided by Antarctic research to answer fundamental questions about global environmental processes.

Protection of the Antarctic environment is a priority for the Howard Government, and in this regard I follow with great interest Australia's efforts on the ice and in the Southern Ocean. For example, an instrumental piece of work, in which Australia's Antarctic scientists can take great pride, is the contribution to understanding and managing the resources of the Southern Ocean.

The international impact of our recent efforts in the Convention on the Conservation of Antarctic Marine Living Resources have directly met the Government's goals of influence within the Antarctic Treaty system and protection of the Antarctic environment. Similar results are coming from our atmospheric and oceanographic programs, and our environmental management activities are among the best.

The quality of our effort in Antarctica is by any measure outstanding. We still have a lot to do, and I am excited by the range of scientific opportunities. It is important that our effort be maintained, and that we make sure that the rest of the world's Antarctic community sees the results of our work.

The Australian Antarctic Magazine will be an ideal forum for reporting our accomplishments in Antarctica, on the subantarctic islands and in the Southern Ocean. I am delighted that it has been launched.

Federal Environment Minister Robert Hill

From the Director

Welcome to this first issue of *Australian Antarctic Magazine*. Our aim is to reach out to the wide community of people who share an excitement about Antarctica. Its successful predecessor *ANARE News* has enjoyed an over-long sabbatical. It is my hope that you will enjoy this magazine and, through its pages, become more aware of the diversity of the Australian Antarctic program and Australia's commitment to Antarctica. *Australian Antarctic Magazine* will report on the current work of the Australian Antarctic program, look forward to the future, and reflect on the achievements of the past.

During the past two years we have been implementing the Government's response to the Antarctic Science Advisory Committee's Report *Australia's Antarctic Program Beyond 2000—a Framework for the Future*. The Government set us four ambitious goals: 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. Each issue of *Australian Antarctic Magazine* will report on what we are doing to meet these goals.

A key challenge for the Antarctic program is to ensure consistently high quality results are achieved with maximum efficiency in all the areas of our work. In doing this we are staying alert to opportunities to do better. This year we are looking very carefully at a number of matters including air transport to, and within, Antarctica; the potential for joint use of facilities and logistics; the development of a more flexible program; multi-ship operation; and enhanced automation of scientific equipment. 2001 is an exciting time for the Antarctic program.

Plans for air transportation to Antarctica and enhanced air support for science on the ice are currently being developed, and will be subjected to close scrutiny for their likely environmental impact before any recommendations are made to Government.

We are developing a ten-year strategic plan for our operations, questioning every aspect of our present activities and asking if by doing things differently we can save resources for deployment elsewhere.

Discussions are being held with other nations to see if savings can be made through cooperative use of logistics.

We are now in the first year of a three-year charter period in which we will operate two vessels to support the Antarctic program. The *RSV Aurora Australis* is spending a greater proportion of her time as a scientific platform.

The Science Branch of the Australian Antarctic Division has embarked upon a rolling program of instrument automation, with many experiments now running automatically.

There have been other changes too. In 1999 we reorganised the Biology Program to allow the Antarctic Marine Living Resources Program to develop its national and international visibility. Australia maintains a high profile in the Convention on the Conservation of Antarctic Marine Living Resources and has been very successful in having its scientific findings on krill and fish stock assessments translated into international agreements. As I write, the atmospheric sciences effort is being reformed into two programs—the Meteorological Science and Atmospheric and Space Physics programs. This change will better focus their activities on the global climate system. The deployment at the start of this season of the LIDAR instrument at Davis marks a significant development in Australia's middle atmosphere climatology research, and the science community is looking forward eagerly to the research results.

An environmental management system is being put in place which will cover all of our activities in the Antarctic and at the program's Kingston headquarters.

Within the Antarctic Treaty we have a number of initiatives being developed in partnership with the Department of Foreign Affairs and Trade and other agencies, all directed at delivering on our goals of maintaining and enhancing the Antarctic Treaty system and protecting the Antarctic environment.

Finally I must pay tribute to the high professionalism of the staff of the Australian Antarctic Division and other participants in the Australian Antarctic program. Their teamwork and commitment shines through in everything they do and I am hopeful that over time our readers will better come to know our Antarctic program and all the people proudly associated with it.

I hope you enjoy *Australian Antarctic Magazine*. Please let us know what you think of it.

Australian ANTARCTIC MAGAZINE

Autumn 2001

The Australian Antarctic Division (AAD), an agency of Environment Australia, 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, maintaining four permanent Australian research stations, and conducting scientific research programs both on land and in the Southern Ocean.

Australia's four Antarctic goals

- 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
- To undertake scientific work of practical, economic and national significance

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

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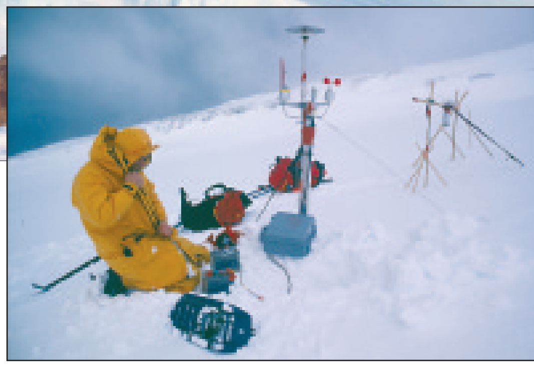
Environment Australia
Department of the Environment and Heritage

Cover—*Australia's Antarctic Program starts the new millenium seeking to understand the role of Antarctica in the global climate system and to protect Antarctica and all of its special qualities.*

Photographs—*Front, clockwise left to right: Andrew Klekociuk, Steve Nicol, Wayne Papps, Doug Thost, Gavin Johnston, Wayne Papps, Diana Calder.*
Back, clockwise left to right: Wayne Papps, Pauline deVos, Kim Pitt, Stephen Brooks Clive McMahon and Anna McEldwney, Steve Nicol, Australian Antarctic Data Centre, Wayne Papps. Iceberg in background: Diana Calder.

Wayne Papps



Doug Thost

Cool Science for the Third Millennium

"We stumble and struggle through the Stygian gloom; the merciless blast—an incubus of vengeance—stabs, buffets and freezes; the stinging drift blinds and chokes"
Sir Douglas Mawson, *Home of the Blizzard*, 1915

Sir Douglas Mawson's sojourn in the eastern part of Antarctica marked the start of Australia's national scientific expeditions to the southern continent. Over the years, the reasons for a national presence have evolved and today Antarctica is a continent set apart for peace and science. Generations of Australian scientists have fought the *incubus of vengeance* to the point where Australia's science program in the Antarctic is as sophisticated as that carried out anywhere; indeed the extreme nature of the environment has spawned the development of novel and ingenious ways of doing things. The success of the Australian program comes from blending the spirit of those who crave to face Antarctica's challenges with scientific and engineering ingenuity. Sir Douglas could hardly have dreamed of the program we are running in the 21st century, but I think he would be proud of it.

What we have learned about the natural sciences in Antarctica over the last forty years or so is that Antarctica is not simply a far distant and remote place, with a climate that makes a challenge of the simplest of activities. We now know it is an integral part of Planet Earth generating much of Australia's weather, powering currents in the world's great oceans, and perhaps being the canary in the polluted earth's coal mine. Scientifically speaking, Antarctica has ceased to be an interesting oddity and now takes a central place in our understanding of major global phenomenological problems.

This article looks at three areas of the modern Australian science program that address the biggest of global issues of our time, and looks forward to the future.

Climate science

The problems with the world's climate are becoming increasingly apparent. Unequivocal evidence exists of a rise in carbon dioxide levels during the past 200 years to unprecedented levels. Almost certainly this is the result of man's activities. Australian work on the analysis of an ice core, taken from the icecap at Law Dome near Casey Station, is confirming data from other Antarctic ice analyses and assisting us in drawing an accurate picture of the history of Antarctic climate. The Australian core is particularly significant because it comes from a region with high precipitation, allowing a high resolution of the climate over the past 80,000 years. So good is the record that chemical markers from the air trapped in the ice allow us to pinpoint ancient volcanic eruptions, and trace the history of the world's biological productivity.

There is no doubt that climate is changing. An international study, Regional Sensitivity to Climate Change, has recently been established, with Australian scientists taking a leading role. Climate change has measurable consequences. Changes in the distribution of plant species and their microhabitats can be used to make predictions about the future, and changes in the rates at which genetic mutations occur gives us a clue about how climate change is a factor in evolution.

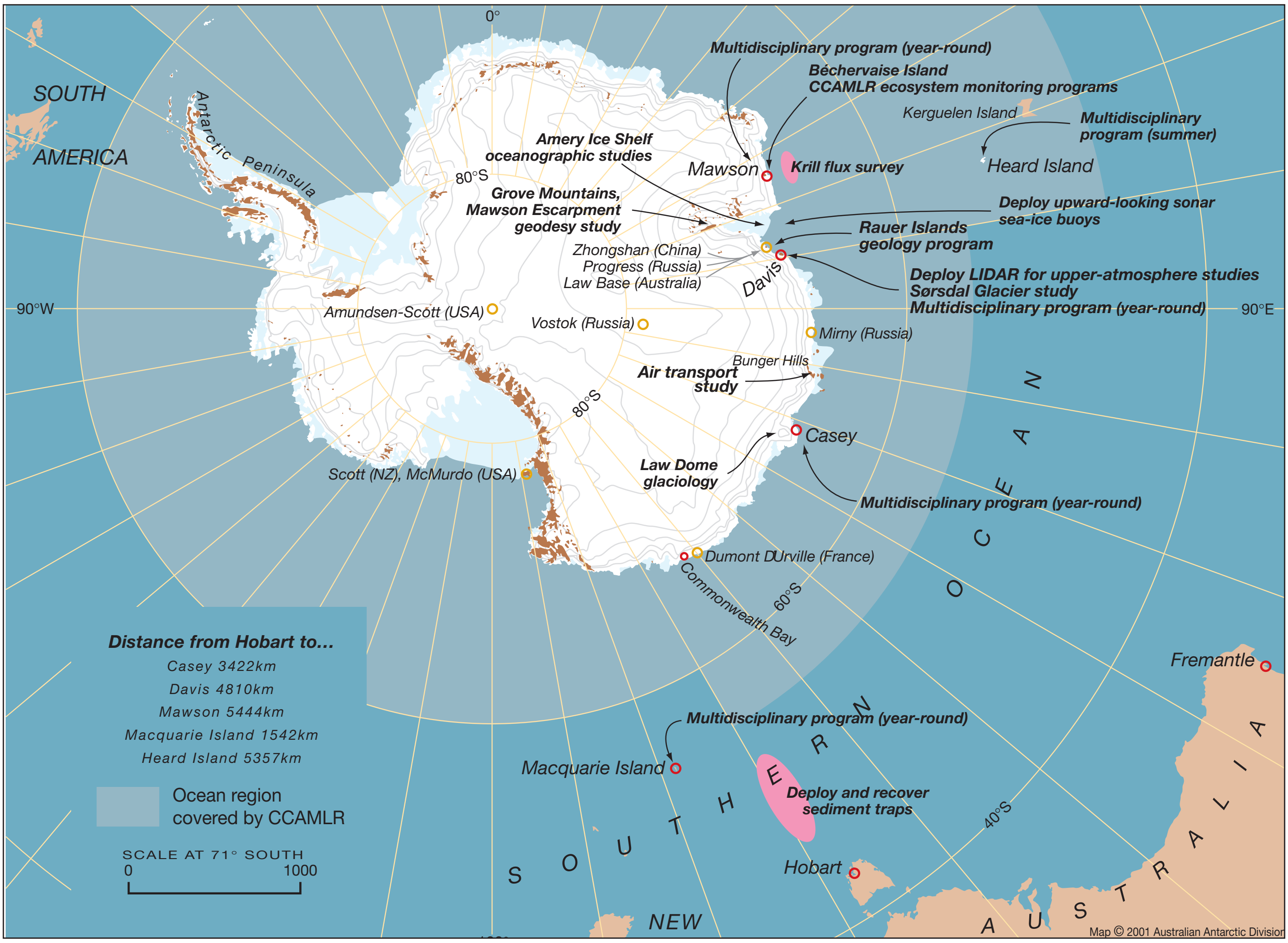
Warming of the earth's surface and its lower atmosphere leads to cooling in the upper atmosphere. This, in turn, leads to an increase in high-altitude ice-clouds that provide the substratum upon which the chemical reactions for the breakdown of ozone occurs. The ozone hole over the Antarctic is now a closely monitored international signal of global health but we do not know enough about the climatology of the middle and upper atmosphere.

High above the earth, between 80 and 100 km in a region that includes the mesopause, the evidence is that the coldest region of the atmosphere (cooler than -140°C) is cooling more dramatically than expected. Cooling rates of 0.7°C per year have been reported from northern hemisphere measurements. It has also been observed that noctilucent or 'night shining' ice-clouds that form at an altitude of around 83 km, mainly in summer in polar regions, are increasing in occurrence and extent. Statistics on southern noctilucent cloud occurrence are sparse and trends are presently unknown. Either increased water vapour at these altitudes resulting from enhanced methane release at ground level, or enhanced cooling, have been postulated as reasons for their increase. Monitoring of this extreme climate region in Antarctica to find out what is happening is an important step in our understanding of climate change.

Physicists at the AAD and University of Adelaide have developed a novel ground-based instrument that accurately profiles temperatures in the stratosphere and mesosphere. The instrument, known by its acronym LIDAR (Light Detection and Ranging), is essentially an optical form of radar. The LIDAR sends pulses of green laser light into the atmosphere in a narrow beam. Atmospheric gases along the beam scatter some of the light back to the instrument where it is collected by a large telescope. The altitude from which the scattered light is received is determined by timing how long it takes the signal to arrive after each laser pulse. The scattered light carries with it a signature of the amount of vibration and hence temperature of the gases in the form of a slightly larger range of colours. An optical device known as a Fabry-Perot spectrometer is used to very precisely measure the range of colours in both the outgoing and collected light. From this information a determination can be made of the average temperature of any point from the ground to about 90 km altitude. Measurements are also made of the speed and wind direction along the LIDAR beam. The instrument was installed at Davis in late 2000 to investigate the climate of the polar atmosphere at high altitudes to improve global climate prediction.

Sustainable harvesting of the Southern Ocean

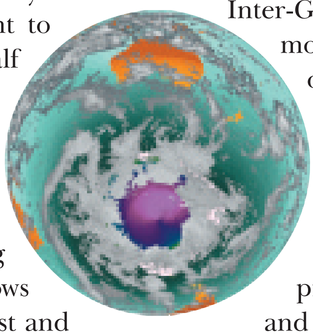
The Southern Ocean is a vast and seemingly limitless place. Once the home to vast numbers of whales and seals it has changed radically in living memory. We know very little about the marine ecosystem close to the Antarctic continent yet continue to rely heavily upon it, and we expect to continue to catch fish and seek out new fisheries as the old are depleted. Australia takes a leading role in the scientific underpinning of the



PETER BOYER

decisions made by the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR)—the only international convention to which Australia is host. Last year, Australia completed a survey of pack-ice seals (crabeater, Weddell, Ross) around one quarter of the Antarctic coastline. This was a complex and tricky activity that required precision flying and ship navigation, and sophisticated computer software for recording—as well as some luck with the weather! The data are currently being processed and they will give, for the first time ever, an accurate picture of the extent of the pressures that predators exert on krill, and with which humans are in competition.

But predators of krill are only one component, albeit a highly visible one, of a complex ecosystem. A massive interdisciplinary study has been undertaken by Australian Antarctic Division scientists with involvement from those at CSIRO, the Antarctic CRC, IASOS, Tokyo Fisheries University, Flinders University and the University of Washington. This has focused on the biology and oceanography of 3,500 km of ice-edge zone from 80 to 150ºE. Far from being a homogeneous pond, the most productive waters occur in two main areas: coastal and shelf areas south of the southern boundary of the Antarctic Circumpolar Current, and regions where the sea ice extent in winter is greatest. Here the concentrations of microscopic marine organisms support vast swarms of krill, which themselves support an abundance of penguins, seabirds, seals and whales. In the east of the AAT, where the winter extent of sea ice is minimal, the fauna is dominated by the jelly-blobs of salps; apparently inedible creatures able to support only an impoverished food chain. These data help us to set appropriate krill catch-limits and to predict the possible biological consequences of global warming which may further reduce the sea ice extent—already thought to have shrunk by almost 30% in the last half century.



Ocean circulation

The circulation patterns of the southern oceans are far from simple. Driven by winds of the howling westerlies and screaming fifties, the Antarctic Circumpolar Current flows from west to east. This current is the longest and has the largest flow in the world. It connects the deep flows of the Atlantic, Indian and Pacific Oceans as part of the global thermohaline circulation. These raging gales set up the heavy swells and switchback seas that have laid low many an Antarctic traveller! But Antarctica generates its own particular wind patterns. The cold katabatic winds that flow down to the coast from the icy interior—Mawson's incubus—gather speed until they burst out onto the ocean with ferocious force. A study conducted during the winter of 1999 at an ice-free area off the Mertz Glacier showed that the wind scoured away the ice as it was forming and transported it up to 90 km in a day. The rate of removal of ice as it was forming amounted to an annual production of about 10 metres—far higher than in areas where the katabatic winds are less severe. Since only freshwater freezes into ice, the water that remains becomes increasingly salty, and accordingly becomes denser. Sinking to lower depths, it spills over the edge of the continental shelf and onwards down into the abyssal depths. From there it heads north, gradually warming and rising when it is well into the northern oceans. Cold water carries more oxygen that warm, so as it rises it re-oxygenates the upper layers. Dissolved nutrients lying in the abyssal deep are brought to the surface, providing the nutrient substratum for swarms of microscopic plankton. The Mertz polynya study brought together AAD glaciologists, CRC and CSIRO oceanographers, and marine biologists, and made great use of remote sensing and satellite technologies. It is opening up new windows on ice, wind, ocean currents and biological productivity.

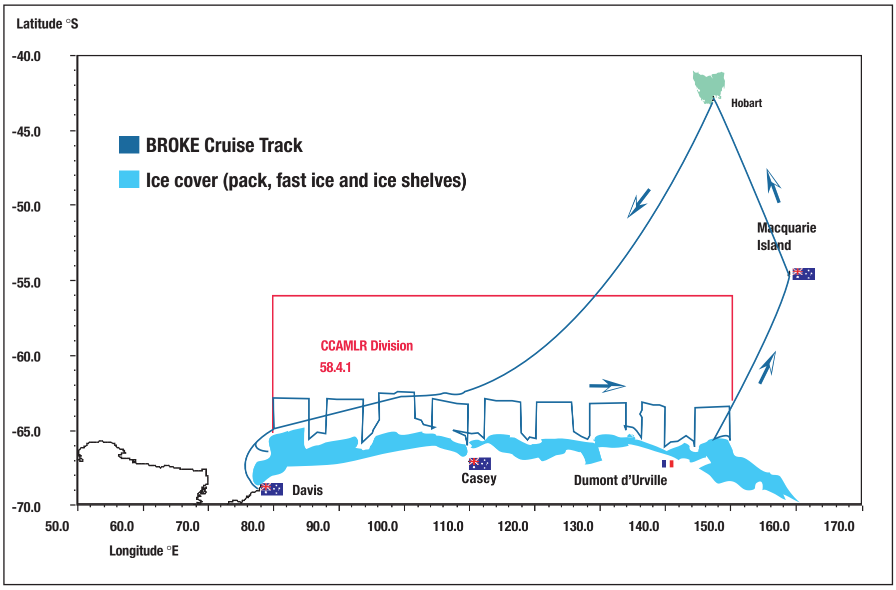
What of the future?

The future for Antarctic science is an exciting one. New technologies, particularly in the field of remote sensing, will begin to contribute data on a range of phenomena including ocean productivity and ice cap thickness. LIDAR, and the new TIGER radar (situated in Tasmania but beaming out over eastern Antarctica) will contribute data on climate change in the mesopause and disturbances in space weather, respectively. Repeated surveys of plant abundance and distribution on the continent and on Heard Island, where invertebrate distribution is also being measured, will give an indication of the speed of climate change, now thought by the Inter-Governmental Panel on Climate Change to be more rapid than previously forecast. Repeated ocean traverses will indicate the extent to which seawater temperature and chemistry are changing, and large-scale marine biodiversity surveys will continue to link biological and physical change.

The next decade will see Australia making progress in cleaning up abandoned work sites, and developing the technologies necessary for handling increasingly friable drums and tanks.

But perhaps the most exciting outcome of the next decade will come from analyses of multi-year/decadal trends that lie hidden in the long-term data sets that are now accumulating. As automation and remote sensing technology are more and more widely and universally used, the flow of data about Antarctic phenomena will quickly become a torrent. Already many scientists are showing interest in a phenomenon known as the Antarctic Circumpolar Wave, a wave of anomalies in sea surface

Sea ice, circulation and the East Antarctic ecosystem



BROKE (Baseline Research on Oceanography, Krill, and the Environment) survey of the waters of East Antarctica, January to April 1996.

The Southern Ocean is renowned for being a highly productive region: the vast stocks of krill, the populations of whales that once fed off them and the emblematic hordes of seals and penguins all make their living from the waters that surround the Antarctic continent. Intensive studies over the last thirty years, however, have shown that these waters are only productive in restricted areas and during a relatively short season. Furthermore, there can be great differences between years in the ability of the ocean to support the plethora of life that depends on it. Recently, a number of theories have put forward to explain the temporal and spatial variation in the productivity of the Southern Ocean. These theories have viewed the physical factors such as sea ice and the major ocean boundaries as being the fundamental determinant of where and when productivity occurs. Winter sea ice is seen as a nursery area for krill which are nurtured by the algae growing on the underside. The more sea ice, the more sea ice algae and therefore the better the krill population survives and this success is propagated up the food chain. The boundaries between currents are seen to be areas where nutrient-rich cold, deep waters reach the surface, thus fuelling the production in spring. A combination of the temporal variation in the abundance of winter sea ice and the geographic location of the major fronts will determine which waters are more productive in a given year. Unfortunately, such large-scale phenomena are difficult to study and most of the information fuelling these theories has come from small-scale studies, mostly in the atypical Antarctic Peninsula region or from inferences from historical data. Until recently no survey had covered enough ocean in a single season to be able to examine some of these relationships in detail.

In 1996 the Australian Antarctic Program embarked on a major voyage which subsequently became known as BROKE (Baseline Research on Oceanography, Krill and the Environment). This voyage surveyed the biology and oceanography of 873,000 km^2 of the waters off East Antarctica. These waters had never been surveyed for krill before, so one of the aims of the survey was to estimate krill abundance to enable a catch limit to be set on the fishery. Similarly, there was little information on the oceanography of this region. A second aim of this voyage was to determine whether there were major sources of Antarctic bottom water along this coastline that might be important from the point of view of climate change. The voyage also studied a whole range of other biological and physical variables from ocean chemistry to the distribution of whales. This provided a unique data set which could be used to examine some of the ideas about the factors determining regional productivity.

Fortuitously, the area surveyed, between 80 and 150°E, is an area in which the winter sea ice extent varies by a factor of three from west to east. Thus the effect of the differences in sea ice extent between the west and

to page 6

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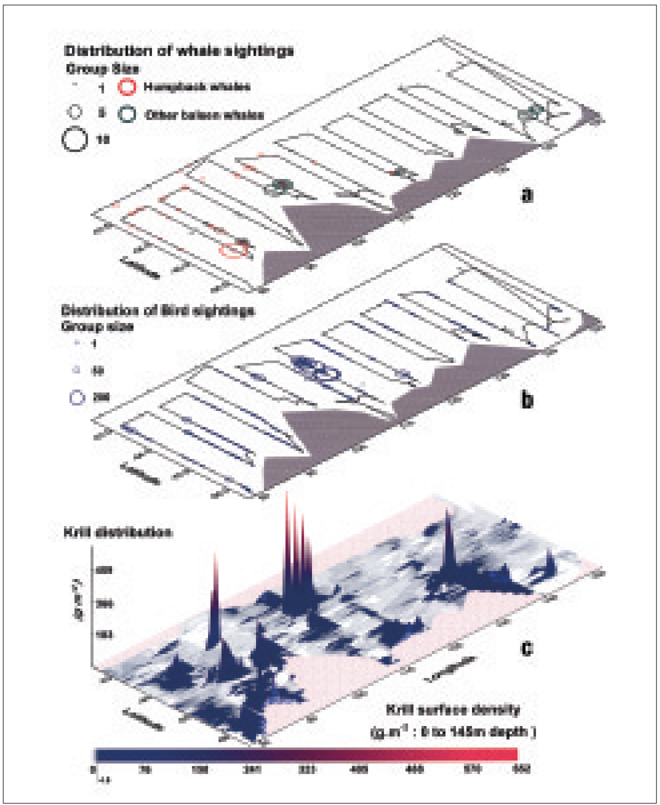
from page 4

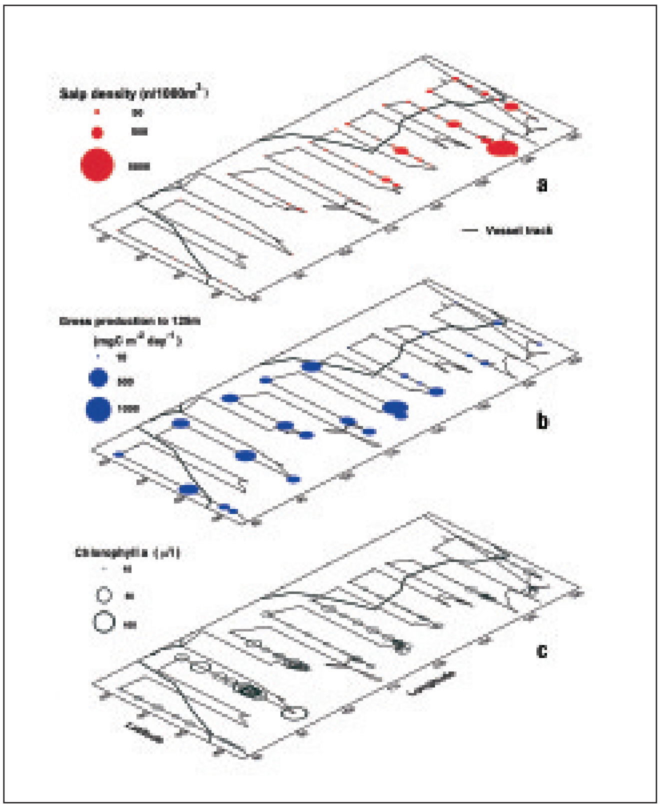
temperatures and surface air pressures, that appears to take about eight years to sweep right around Antarctica. Two waves are rolling around, so every four years or so each location experiences the changed conditions. Does this fascinating phenomenon influence biological productivity, or the amount of water locked in the vast ice cap, or the periodic failure to live to fledging age of Adélie chicks, or the extent of winter sea ice? We do not know yet, but in ten years we might.

I am grateful to Drs Nathan Bindoff, Ray Morris and Steve Nicol for their help with this article.

Professor Michael Stoddart, ANARE Chief Scientist, AAD



*Distribution and abundance of whales, seabirds and Antarctic krill off East Antarctica, austral summer, 1996. a, Whales. b, Seabirds. c, Antarctic krill (*Euphausia superba*) in grams per square metre. BROKE survey track is indicated.* © Nature



*Distribution and abundance of salps, primary productivity and chlorophyll-*a *off East Antarctica, austral summer, 1996. a, Salp (*Salpa thompsoni*) density (individuals per 1,000 m*^{3}*). b, Gross production in mg C per square metre per day. c, chlorophyll-*a *stock in milligrams per square metre. The BROKE survey track and the reported position of the southern boundary of the Antarctic circumpolar current are indicated.* © Nature

the east on the distribution of biological production at all levels, could be investigated. In the west of the area (80-115°E) there was much greater biological activity; primary production was greater, and two-thirds of the krill biomass and nearly all the whales were located there. Production also stretched far north in a gyre which retained the cold water with which the productivity is associated. In the east, the warmer water of the Antarctic circumpolar current veered southward and the cold productive water was confined to a narrow coastal band. Consequently all forms of life in the 115-150°E sector were more scarce than in the west. The patterns observed were distinct throughout the physical and biological data and pointed to the water circulation enhancing production in the western half of the region.

Putting all the data together, it became apparent that the factors that were controlling the distribution of the living organisms were also probably controlling the distribution of the physical variables too. So rather than the sea ice determining the level of biological production, it is the circulation that determines both the biological productivity and the location where the sea ice is most extensive—they co-vary rather than one causing the other. We have used this insight to suggest that what we see off East Antarctica may be a geographic reflection of what is seen in other regions of the Antarctic. In seasons when there is more sea ice, this may be because the circulation pattern has pushed the warmer water offshore and the colder, more productive water dominates the coastal areas. When there is less sea ice this is because the warmer, less productive water is closer to the continent and the animals associated with the krill-rich cold water are displaced.

This new concept of how the Antarctic marine ecosystem functions was published late in 2000 in a special volume of the journal *Deep Sea Research* containing thirteen papers on the results of the research from BROKE and simultaneously in a conceptual paper in the prestigious British weekly science journal *Nature*. Additionally, the results were used by CCAMLR at its 19th meeting to set two new precautionary catch limits on the krill fishery off East Antarctica—277,000 tonnes west of 115°E and 163,000 tonnes east of 115°E in any fishing season. The scientific and management achievements of this voyage must make it one of the more successful activities undertaken by the Australian Antarctic Program.

Stephen Nicol, Antarctic Marine Living Resources Program Leader, AAD

Antarctic pack-ice seals count

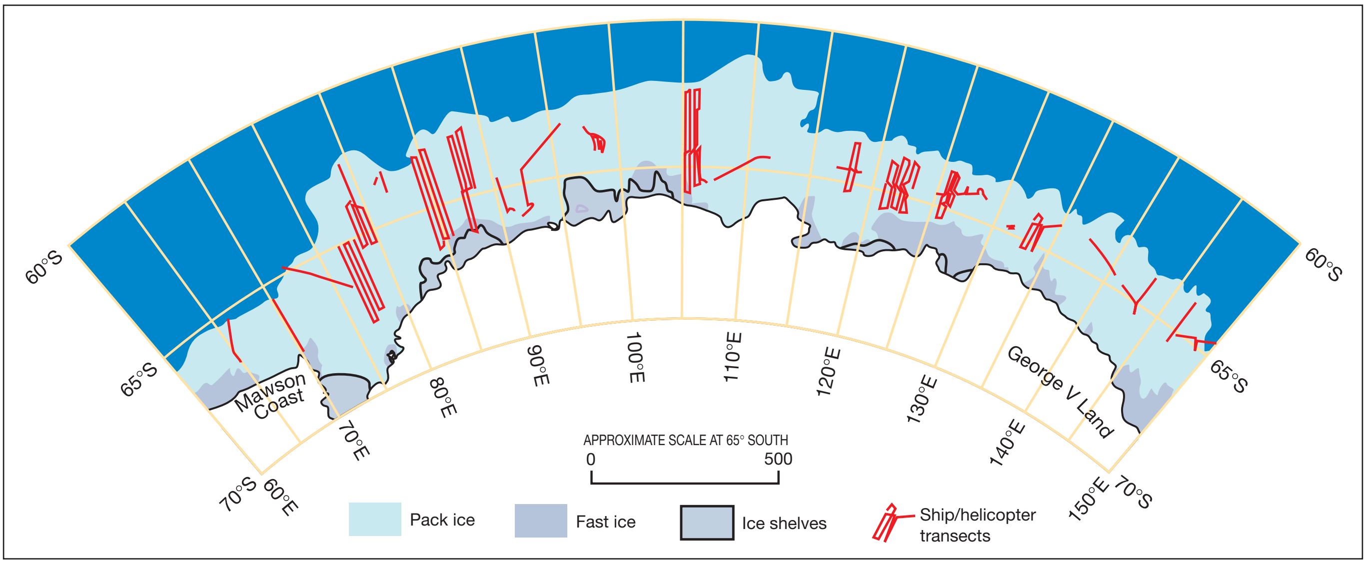
Grant Dixon

The living resources of the Antarctic region have been harvested for over two hundred years with seal, whale and fish populations being severely depleted by unsustainable practices. Sustainable harvesting of biological resources in the Antarctic region requires a precautionary approach and knowledge of the structure of the ecosystem. Seals and penguins are heavily dependent upon Antarctic krill—a species of prawn-like crustacean which has been subject to substantial fishing pressure over the last 25 years. The importance of Antarctic krill to life in the Southern Ocean near the Antarctic ice edge is reflected in a major Australian program whose objective is to understand the structure of this important ecosystem.

For some years the numbers of Adélie penguins breeding at Bechervaise Island near Mawson Station has been subject to annual census as part of Australia's contribution to an international ecosystem monitoring program coordinated by the Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR), the body responsible for managing fishing in the Antarctic region. We are beginning to understand how their population fluctuates in response to environmental variability, particularly inter-annual changes in their food supply.

The same cannot be said for the crabeater seal which inhabits the pack-ice encircling the Antarctic continent. Contrary to what is suggested by its name the crabeater seal does not eat crabs but Antarctic krill. As crabeaters are by far the most numerous of the pack-ice seals an accurate estimate of their numbers is crucial to our understanding of ecosystem dynamics.

During the 1960s the world population of crabeater seals was estimated at between 12 and 70 million but a more precise count was not possible on account of serious flaws in the methodology used. For our current studies on the dynamics of the Southern Ocean ecosystem an accurate estimation of the abundance of these important krill-harvesters is of the utmost importance. Crabeater seals may be the major overall consumer of krill even



Peter Boyer

surpassing the depleted great whales, and knowledge of their population numbers is an essential part of the equation balancing krill stocks with all species—including humans—which harvest them.

The idea to mount an international, circumpolar survey of pack-ice seals was born almost a decade ago through discussions between CCAMLR and the Scientific Committee on Antarctic Research (SCAR). In 1994, six nations (Australia, USA, South Africa, UK, Norway and Germany) commenced a five-year program aimed at developing a standard methodology which all participating nations could utilise. The Australian Antarctic Division program took a leadership role in developing and coordinating this task, deemed as one of the most taxing and difficult wildlife surveys ever undertaken.

The survey, carried out between November 1999 and January 2000 involved two different but integrated activities. Counts of seals hauled out on the ice were made from the ice-breaking research vessel, the *Aurora Australis* and from long-range helicopters. Seals were captured for the attachment of electronic tags, which transmit data over a satellite link on their diving behaviour. These data allow a calculation to be made of the proportion of the population below the water—and therefore invisible—at any one time. When the two data streams are combined, an accurate assessment of seal density can be derived.

Each activity has its challenges. Unlike most wildlife surveys, in the harsh Antarctic environment it is not possible to plan exactly how each daily program will be run. The survey required several long passages running south from the ice-edge to the continent. The ice was often too thick for the *Aurora Australis* to penetrate and the weather was generally cloudy, making aerial survey difficult.

Attaching dive recorders to seals requires a team of people to catch and sedate a seal when it is hauled out

COLIN SOUTHWELL

on an ice floe. On a small floe, with 200 kg of surprised seal and in bitterly cold weather, this is a difficult and potentially dangerous operation. The seals are sedated using a dart gun loaded with anaesthetic and when sedated the small recording instrument is glued to the seal's back. It falls off when the seal moults, in late December or early January.

Our survey covered just short of a quarter of the entire circumpolar region, from 150°E near the French station of Dumont d'Urville, to 63°E near Mawson station. Our helicopters flew some 8000 km of survey tracks over 1 million square km of pack ice, and the ship chiselled a 2000 km route. A total of twenty-five seals have had dive recorders attached, including two that were attached to Ross seals—an extremely rare and little-known species. Dr Colin Southwell from the Australian Antarctic Division led the team of fourteen wildlife biologists, a veterinarian and an electronics engineer. Together with weather forecasters, helicopter and ship's crews, the team worked shifts round the clock during the twenty-four days' duration of the work.

The data from the survey will take many months to analyse, and even longer to integrate with those collected by other participating nations. But in the end we will know far more about the ability of the Southern Ocean to support sustainable managed fisheries—important information as a protein-hungry world plunges on into the 21st century. Australia can be justly proud of its leading role in this ambitious and timely international collaboration.

Colin Southwell, Antarctic Marine Living Resources Program, AAD

Helen Achurch and Kelvin Cope setting up aerial survey equipment in a Sikorsky helicopter. This equipment, designed by engineers at the Australian Antarctic Division, is a major advance in wildlife survey technology COLIN SOUTHWELL

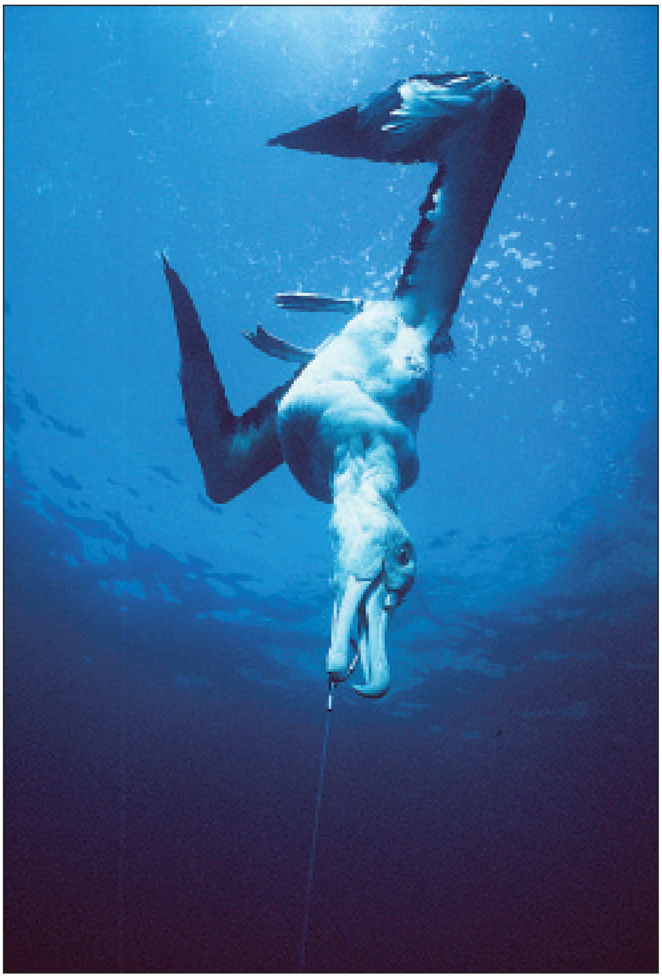
Can albatrosses and longline fisheries co-exist?

Food from processed fish expelled into the sea turns fishing boats into the equivalent of floating restaurants for seabirds, often with fatal consequences. Seabirds are unlikely to tell the difference between fish offal floating on the surface and baits with hooks buried inside them. Until they bite something crunchy, that is. GRAHAM ROBERTSON

DOWN THE YEARS, IN SOME PARTS OF THE WORLD, albatrosses and people have had a hard time living together. Albatrosses have been shot and clubbed to near-extinction for feathers and meat, they've been fire bombed and bulldozed to make way for airfields, and the waters they feed from have been so polluted by industrial waste that vast numbers of chicks have died from junk fed to them by their parents. That they've survived all this is a credit to their powers of regeneration, but the newest threat—death by drowning in longline fisheries—is relentless and the birds could become extinct if mortality rates remain unchecked.

The 24 species of albatrosses roam the world's oceans south of 30°S and north of 30°N, for these are the windiest latitudes and albatrosses need the wind to fly. They're remarkable fliers, and it takes only a mild stretch of the imagination to think that an albatross living at, say, the Chatham Islands in New Zealand but wishing to cross the Pacific to rich South American feeding grounds could on the same day have breakfast in New Zealand, lunch in Tahiti and dinner off the coast of Chile or Peru. The time span for this flight might be fanciful but the implied ease in traversing one of the world's largest oceans and the ability to feed in someone else's waters are not. And this is why albatrosses get into trouble: distance is no problem and they prefer the same waters as do longline fishing vessels. These waters lie over continental shelves and their margins, and along frontal zones where water masses mix and upwell. Longline vessels frequent these areas targeting pelagic fishes (i.e. tuna, swordfish) and bottom-dwelling fishes (i.e. ling, hake, cod, halibut, sablefish, Patagonian toothfish) on longlines that might measure 130 km in length and carry as many as 40,000 hooks. Longliners also discharge waste from processed fish which not only supplements the diets of seabirds but encourages them to stick around, thereby exposing them to line setting operations when baited hooks are deployed.

Albatrosses get hooked (and drowned) when they attack baited hooks that are set without protective measures (the most effective measures are setting lines deep underwater, setting lines at night, adding weight to speed up sinking rates, flying streamers to scare birds off baits, disguising baits with dye and discharging fish



Designed for tuna and swordfish, the hooks on pelagic longlines sometimes end up embedded in the bills of unsuspecting wandering albatrosses. When the longline sinks the 'albies' do too. This bird, from South Georgia in the south-west Atlantic, met its fate in the longline tuna fishery off eastern Australia.

Graham Robertson

offal discretely). In the Southern Ocean, where most albatross species range, it is likely that tens-of-thousands of albatrosses and other petrel species are killed annually, and this is threatening the survival of many populations.

Mortality is probably highest in the illegal fishery for Patagonian toothfish, where pirate vessels don't carry independent observers and probably don't use protective measures. It is also high in the Indian Ocean tuna fishery, because of the large number of albatrosses in that part of the world, the difficulties of managing fisheries in international waters, and the lack of observers on vessels.

A peculiarity of the problem is the low numbers of albatrosses caught by individual longliners, and this is one reason why sectors of the fishing industry have resisted the notion that their industry causes populations to decline. The explanation lies in the nature of the birds themselves: albatrosses are long lived, take a long time to mature and they don't breed like rabbits. Push mortality above levels they're not designed to cope with and you start an insidious slide into the abyss. The hard part is the invisible nature of the problem, because unlike the harvesting for meat and feathers mentioned above—which occurred on land and could be seen if not measured—mortality from longlining occurs at sea, is often out of sight and out of mind, hard to measure and very difficult to control.

Albatrosses are hard-wired by nature to do what they do and can't be changed—diving down on fish near the sea surface is a difficult behaviour to modify! What can be changed is the attitude of agencies and people responsible for the stewardship of the oceans, and change is occurring, albeit slowly. Solutions are being developed at international and national levels, by governments and researchers and by some fishermen. The initiatives of greatest importance, because of their global co-ordination roles, are those by the UN's Food and Agriculture Organisation (FAO), the Agreement on the Conservation of Albatrosses and Petrels, the Global Environment Fund and the Commission for the Conservation of Antarctic Marine Living Resources.

The FAO has produced an international plan of action to reduce seabird mortality in longline fisheries. This calls for all nations with longline fisheries to produce plans on how they intend to deal with the problem. The production of a national plan usually involves an assessment of the nature and extent of seabird mortality by fishery type, adoption of seabird bycatch mitigation measures (which might involve at-sea research to determine best practice), inclusion of bycatch regulations in fisheries management legislation and the use of independent observers on fishing vessels. Some nations have completed their plans and several nations have theirs in the draft stage; participation is, of course, voluntary and time will tell how attentive and genuine longlining nations have been in responding to this important FAO request.

The Agreement on the Conservation of Albatrosses and Petrels of the southern hemisphere (ACAP) stems from the listing of 14 species of albatrosses with unfavourable conservation status in the appendices of the Convention for Migratory Species of Wild Animals. As the Chatham Island example above indicates albatrosses on migration flights frequent the waters of many nations, hence the importance of multi-nation agreements to protect them throughout their entire migratory ranges. The Agreement pertains to States that exercise jurisdiction over any part of the range of albatrosses and petrels, as well as distant water fishing nations that interact with albatrosses and petrels while fishing. Parties to the ACAP will be obliged to achieve and maintain the favourable conservation status of albatrosses in both terrestrial and marine environments. This initiative is complementary to that by the UN's FAO since the protection of albatrosses in marine environments will require, essentially, the production and implementation of action plans as sought by the FAO.

Pivotal to ACAP success is a high degree of collaboration between participating nations at government level. Collaboration is also occurring from the bottom up. In 1999 Australia, Chile and the United Kingdom teamed up to train a Chilean PhD student in the ecology of albatrosses breeding in southern Chile, including interactions with fisheries. Destined for completion in 2002, this study is the first of its kind for a South American and is an important grass-roots attempt to generate the knowledge and human resource-base upon which the albatross conservation effort depends.

This year a BirdLife International sponsored meeting will be held in Cape Town to prepare an application to the Global Environment Fund seeking financial help for developing nations to produce plans of action to FAO requirements. Countries that stand to benefit include South Africa, Ecuador, Peru, Chile, Argentina, Uruguay and Brazil. The waters of these nations support large longline fisheries and are rich feeding grounds for albatrosses from many parts of the world.

The Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) is a 24-nation organisation responsible for overseeing the ecologically sustainable use of living resources in the Southern Ocean, and has been a leader in attempts to get albatrosses off the hook. The CCAMLR area (see map on p 53) includes the entire Southern Ocean from Antarctica to the northern limits of Antarctic waters, which is roughly about half way between the Antarctic continent and Australia, and is an area which includes many albatross breeding islands and foraging waters. So far as albatrosses are concerned, longline fishing in these waters means the legal and illegal fisheries for Patagonian and Antarctic toothfishes, which occurs from 500 to 2,500 metre deep around the margins of Antarctica and subantarctic Islands and the coasts of Chile, Argentina and Uruguay. Since 1995 CCAMLR has promoted the use of albatross-friendly fishing practices in the legal toothfish fishery with mixed results. Even with the existence of easy-to-use mitigation measures seabird mortality has remained unacceptably high, principally because of the lack of full compliance with the measures and because of fundamental difficulties with one of the established methods used to catch toothfish. Consequently the toothfish fishery around South Georgia, an island in the southwestern Atlantic Ocean with one of the largest toothfish quotas, is closed during the eight month albatross breeding season. This most heavy-handed of measures has been necessary to take seabird mortality to safe levels (in the 2000 season 14.5 million hooks deployed caught less than 50 seabirds) and has encouraged some fishermen to try catching toothfish with craypot-like cages instead of hooks.

The biggest challenge for CCAMLR is the illegal toothfish fishery, which is about the same size as the legal fishery. To reduce the sale of fish caught by unlicensed vessels CCAMLR has sought the co-operation of countries offering port and downloading facilities to the illegal trade and introduced a documentation scheme for legally caught fish, the idea being that vessels must produce evidence of licensed fishing in order to sell their catch. However, poaching toothfish and selling it illegally is a lucrative business and only time will reveal the effectiveness of the scheme in curbing the illegal toothfish trade and the associated take of albatrosses and other seabird species.

The surreal beauty and placid nature of these grey-headed albatrosses belies their aggressive behaviour at sea. Great dexterity in the air, speed across the water and diving ability means a competitive edge over other seabirds and increased vulnerability to baited hooks deployed from longline fishing boats. GRAHAM ROBERTSON

The initiatives outlined above paint a picture of international effort, conservation agreements, funding for developing nations and implied change, but it would be a mistake to believe that satisfactory outcomes lie just around the corner. The picture isn't as rosy as it might seem. As the South Georgia (Isla Georgia del Sur) example indicates (where fishery closure was necessary to achieve albatross conservation objectives) the existence of effective mitigation and neat international agreements don't necessarily translate into seabird-friendly fishing practices. Unfortunately the realities of human nature and vested interest tend to get in the way.

When it comes to international agreements, nations are like the people in them: they want to be wanted, to know they matter and to exert influence over issues affecting them—better to be in than out as the saying goes. But the spectre of disingenuousness hovers ever-present in the background: often the tendency is to sign agreements then hurry up and go as slow as possible in effecting real change, to log jam progress in order to preserve the status quo. This behaviour is an unfortunate fact of international life and it's the reason why a persistent top-down approach by people trained to argue with the equivalent of brick walls is an integral part of the global albatross conservation effort.

The key concern is what happens at sea, for this is where each day, during line setting operations, fishing masters make decisions that determine the fate of albatrosses. With 6 metre seas to deal with, 18-hour working days, months or even years away from home and tough working conditions, it's understandable why decisions by governments and even land-based vessel owners about seabird conservation tend to be neglected. The reasonable expectation however, is that vessel owners and fishing masters be pragmatic enough to realise that sustainability is the way of the future and that it pertains not only to target fish species and fishermen themselves but to bycatch species as well, including albatrosses and other seabirds.

Aggravating the situation is the over-abundance of fishing vessels in the world and the global trade in seafood: both encourage illegal fishing and fishing in breach of international agreements intent on sustainable management. The FAO is attempting to reduce the number of fishing vessels in the world, via an international action plan, but this initiative will almost certainly meet considerable resistance and it would be remarkable if anything emerged in the short-to-medium term that was of benefit to albatrosses.

The global trade in seafood encourages overfishing, which means more hooks deployed and more albatrosses caught. Conservation usually works best when nations can see and take responsibility for the environmental effects of lifestyle and consumption, and this can't happen if rich nations import fish taken from international waters or the waters of nations that need the money, and push their fisheries to the limit. To manage fisheries properly you need your hands on the wheel, and it would make better sense if fishing nations developed the capacity to feed themselves from their own economic zones where a sense of ownership can exist and the sustainable management of fisheries would be more likely.

So, can albatrosses and longline fisheries co-exist? This question can be answered in two parts—co-existence inside national economic zones and co-existence in international waters (it's easiest to break the question in two, but in reality the dichotomy is a spatial nonsense and conservation success relies on a co-ordinated effort both inside and outside economic zones). Co-existence between albatrosses and longline fisheries inside national economic zones should be possible but relies on several assumptions: that relevant nations produce effective plans of action, that seabird conservation measures are woven into the fabric of fisheries management legislation (including the potential for punitive action against violators of conservation measures) and that adequate observer coverage of vessels exists. In international waters though it's a different story. In the absence of a panacea (a fix-all mitigation technique that fishermen find beneficial) we are left with voluntary compliance, and that doesn't inspire confidence. I don't expect fishermen to care about seabirds and I don't expect them to use mitigation measures unless they benefit the fishermen—worrying about seabirds doesn't fit well with the culture and practice of longline fishing and the money-making imperative that drives it. In international waters, unless something unexpected happens—like collapse of fish stocks or contraction of fisheries to waters not frequented by albatrosses—then albatrosses and some other seabird species will continue to be taken in large numbers and further population reductions will be inevitable.

Graham Robertson, Antarctic Marine Living Resources Program, AAD

Heard Island's seabirds under scrutiny

Part of the newly discovered colony of Heard Island cormorants at Cape Pillar, Heard Island. ERIC WOEHLER

A CENSUS OF SEABIRD POPULATIONS AT HEARD ISLAND during the 2000-01 summer has provided contemporary data on the distribution and abundance of breeding seabirds in the western two-thirds of the island. The survey, by Eric Woehler and Heidi Auman, collected census and GPS data for seabirds between Cape Arkona in the south-west, parts of the extensive vegetated areas of the Laurens Peninsula in the north-west, and as far as Gilchrist Beach in the north-east. The remainder of Heard Island will be surveyed on the next visit, currently planned for 2003-04.

Predators, such as cats and rats, have been introduced to almost every subantarctic island except Heard Island, and they are known to prey on seabirds. However, without information on seabird populations before human disturbance, it is impossible to fully estimate the damage caused by these predators. Heard Island provides a unique opportunity to understand the population trends and dynamics of subantarctic seabird populations undisturbed by introduced pests.

As seabirds come under additional threats such as long-line fishing, it becomes increasingly important to understand how their populations change over time. On this visit, most of the survey effort was directed towards those species for which long-term data already exist, because building on these data sets is the only way we can begin to understand the variability of long-lived species.

King penguins (*Aptenodytes patagonicus*) were first surveyed on Heard Island in 1948 and southern giant petrels (*Macronectes giganteus*) in 1951. For both these species we are now able to see very marked population trends—one species is growing in numbers very rapidly, the other is decreasing (see below). Population surveys may not provide the reason for these changes but without this information we would not even know they were happening. Attention was also given to rockhopper penguins (*Eudyptes chrysocome*) a species whose numbers are decreasing rapidly elsewhere in the subantarctic, with some populations falling by 90% or more in the last 50 years. In the absence of historical data on rockhopper penguins at Heard Island, it was important to establish reference colonies and obtain baseline population data in case Heard Island's populations of rockhopper penguins also decrease or are already on the decline.

Contemporary data permits an assessment of current population sizes and trends, provides fundamental data for management purposes, including the current revision of the Heard Island Management Plan, and enables the conservation status of several species to be re-assessed. The detailed knowledge of the distribution, abundance and trends of seabirds on Heard Island will also be used for planning future activities on the island, including visits by expeditioners with the Australian Antarctic Program and tourists, to ensure they do not cause harm to the wildlife.

Southern giant petrels

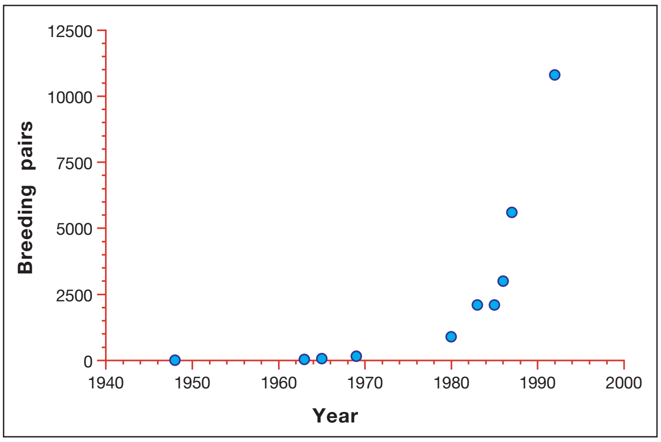
Eric Woehler

Macronectes giganteus breed on many subantarctic islands. The population at Heard Island was first studied by Max Downes in the early 1950s, and a complete island census was first obtained in 1951. During the 1987-88 ANARE, with Max's assistance, the island's breeding population was re-censused. With counts on only two occasions it is impossible to understand the natural variability of the population. However, this work alerted scientists to a halving of the breeding population—from approximately 3,500 pairs in 1951 to 1,700 pairs in 1987. Similar decreases have been documented in other breeding populations of southern giant petrels around the Southern Ocean. Southern giant petrels are known to be easily disturbed by human activities, and it has been suggested that intensive programs of banding of chicks undertaken at many breeding localities in the 1950s and 1960s may have contributed to the observed population decrease. However, the decrease on Heard Island, where there has been little banding, indicates that this is not the full story. The minimal human presence since the closure of the ANARE station in 1954 effectively rules out human disturbance as a contributing factor to the decrease observed since the 1950s. Southern giant petrels are also frequently caught in longline fisheries in the Southern Ocean and this may now be a contributing factor. Ironically, the lack of banded birds from Heard Island makes it impossible to identify which of the southern giant petrels caught by longliners are from this population. At the same time as the giant petrels were declining, the population of southern elephant seals, *Mirounga leonina*, at Heard Island has also decreased by 60%. It may be that similar or parallel processes affect both species and that research to understand one may provide insights to help understand population changes in the other species. Future research may show there are previously unknown links between the species. However, without simple count data these enormous changes in population sizes would have gone unnoticed.

Long-term population recovery of king penguins

Eric Woehler

The sealers on Heard Island during the 19th century made use of king penguins *(Aptenodytes patagonicus)* as food and fuel. While no accurate population data were ever collected, it is believed that the impact of these sealers on the local colonies was so great that they were nearly wiped out. In 1948, during the first ANARE to Heard Island, a small breeding colony of king penguins was recorded at Pageos Moraine, near the Atlas Cove station. Since then, most visits to Heard Island have made attempts to census the breeding colonies of king penguins scattered around the coastline. With seven colonies known in 1992, the population has exhibited remarkable growth (>20% annually), doubling every five to seven years (see plot). Preliminary results from the current survey indicate that this rapid increase is continuing, and that the breeding population at Heard Island shows no sign of reaching its limit. All king penguin populations at other breeding localities in the subantarctic for which long term data are available also show this dramatic increase. The causes for this rapid, sustained and widespread increase remain unknown.



The Heard Island cormorant is more common than thought

Eric Woehler

A previously unknown breeding locality of the Heard Island Cormorant (*Phalacrocorax nivalis*) was discovered in early November 2000. The species was listed as 'vulnerable' under IUCN criteria due to its endemism (breeding only at Heard Island) and small known breeding population, estimated at between 90 and 200 pairs. Three colonies were known: Red Island in the northwest—about 30 pairs; Saddle Point, on the central north coast—about 80 pairs; and Stephenson Lagoon on the northeast coast—about 100 pairs. The sites are difficult to access and had never before been counted simultaneously so an accurate estimate of the total breeding population has been difficult to determine. Biologists were puzzled by observations of more than 600 roosting birds, which is more than the known breeding population. On 2 November, a large colony of 1,000 nests was discovered at Cape Pillar, on the remote and rarely visited southwest coast of Heard Island. The cormorant colony was on the western periphery of a macaroni penguin *Eudyptes chrysolophus* colony (about 25,000 pairs), and as such, very easy to overlook on aerial photographs or aerial inspections. A series of overlapping oblique (ground) photographs were taken to enable a more accurate count, and to supplement the ground counts. Approximately 100 to 200 roosting cormorants were also present at the fringes of the nesting areas. A revised estimate of total breeding population will be made at the end of the season on Heard Island following visits to all colonies. The population has almost certainly always been there but has been previously overlooked. The discovery that the population is larger than previously believed may not change its IUCN classification as 'vulnerable' as the breeding population is found only at Heard Island. However, the larger population means that the species is more likely to survive in the long-term.

The mysterious migrations of Antarctic terns partially explained

Eric Woehler

At Bird Island (33°50'S 26°17'E) in Algoa Bay off Port Elizabeth in South Africa, there is a site that is globally important for Antarctic terns (*Sterna vittata*). More than 10,000 terns roost there nightly during the winter months. Biologists have not known where these birds breed, so between July 1998 and September 2000, two South African ornithologists captured and banded more than 1,000 Antarctic terns and marked 600 of these with bright yellow leg bands to make them easier to spot. There is a small breeding population of Antarctic terns on Heard Island, estimated at less than 100 pairs. They are absent from Heard Island for the winter months and South Africa had previously been suggested as a potential wintering area, although there was no hard evidence to support this. On 31 December 2000, one of six Antarctic terns feeding in the surf and sitting on the shoreline of Atlas Cove was seen to have a yellow band on its left leg. On 2 January 2001, two of approximately 80 Antarctic terns feeding in the surf at Corinthian Bay, approximately 1 km east of Atlas Cove, were observed to have yellow bands, and another bird was seen to have a metal band only. A search at Jacka Valley, approximately 7 km from Atlas Cove on 15 January 2001, and a known breeding locality for terns, was successful. Of 20 nest scrapes located in the colony, two belonged to birds with bands. Heard Island is approximately 4,300 km from Bird Island, South Africa, and these sightings provide the first evidence of migration by breeding Heard Island Antarctic terns to South African wintering areas.

Eric Woehler, Heidi Auman & Martin Riddle
Human Impacts Research Program, AAD

Minimising the disturbance to Antarctic wildlife

The number of people travelling to Antarctica is growing, with much of the recent increase in visitor numbers attributable to an expansion in commercial tourism. It has been estimated that by 2010 as many as 1.5 million commercial tourists could be visiting the region each year (Coughlan 1998), compared to the 12-14,000 that currently travel there annually. Most visitors to Antarctica seek direct interactions with the wildlife and so visit breeding groups of seals and seabirds. Invariably this involves travelling to wildlife breeding sites by helicopter, zodiac or over-snow vehicle, and then making relatively close approaches on foot to photograph and observe the animals.

The sheer number of people likely to travel to Antarctica over the next decade, and their emphasis on visiting wildlife, has highlighted the need for information that can generate practical guidelines to minimise disturbance to breeding animals. As such, the AAD's Human Impacts Research Program is investigating the responses of a range of wildlife species to various human activities associated with tourism and expedition operations. The overall aim of the research is to make quality information available for the development of a comprehensive and scientifically based set of guidelines for managing interactions between people and wildlife in Antarctica.

The research adopts an experimental approach, whereby animals are exposed to controlled human activity while their responses to that activity are objectively measured. Experiments are statistically designed and incorporate high levels of replication to maximise the likelihood of detecting the effects of human activity should they be present. Wildlife response to disturbance is quantified on the basis of a number of parameters, including reproductive success, behaviour and physiology. As such, we hope to address both short-term transient and long-term irreversible effects of disturbance.

Building on initial studies that investigated the minimal approach distances suitable for people visiting breeding Adélie penguins (*Pygoscelis adeliae*), the work has more recently quantified the responses of penguins and surface-nesting petrels to over-flights by helicopters. Results obtained to date have formed the basis of new, more conservative AAD guidelines for people approaching penguin colonies on foot and for helicopters flying over concentrations of breeding seabirds. In addition to being formalised as changes to AAD policy, findings are being disseminated through a variety of media, including tourism newsletters, videos, posters and pamphlets. Other Antarctic Treaty nations, and to a lesser extent commercial tour companies, are readily adopting the recommendations arising from the research and are increasingly looking to the AAD for policy advice and opportunities to collaborate on similar work into the future.

During the 2000-2001 summer we expanded the program further and began a multi-year project investigating the responses of Weddell seals (*Leptonychotes weddelli*) to human activity. In keeping with our previous studies, the Weddell seal program employs controlled, field-based experiments to quantify the effects of actual disturbances to which the seals are presently exposed. The types of stimuli being investigated include approaches by people on foot, and also quad, Hagglunds and helicopter operations. Once again the overall aim is to produce information suitable for the development of practical, well-supported guidelines.

As part of the Weddell seal project, we are also recording the sound generated under the ice by vehicles travelling at various speeds and distances from a sound recording point. It is hoped that this information will enable us to determine whether vehicle activity masks vocal communication among Weddell seals under the ice, or in some way changes their vocal behaviour. Our ultimate goal is to collect information on the in-air and under-water noise generated by a wide range of vehicles and aircraft operating under a variety of conditions (for example, under blue ice, open water, snow-covered ice, or in areas with different bathometry). This information should greatly improve our ability to predict the impact our activities are likely to have on Antarctic marine mammals and seabirds.

Next summer (2001-02), the research will continue to expand with a study investigating the effects of human activity on surface-nesting petrels, particularly Southern fulmars (*Fulmarus glacialoides*) and Cape petrels (*Daption capense*). Once again, an experimental approach will be adopted to enable us to measure how the birds respond to approaches by people and to approaches by small boats with outboard motors. As this is also a multi-year project, it is hoped that in the future, we will begin to investigate the responses of some subantarctic seabird species to human activity.

The ultimate aim of the research will be to continue to establish specific codes of conduct and protocols to be used by the Australian Government and Antarctic tour operators to minimise human interference with Antarctic wildlife. Such guidelines should then contribute to sustainable, recreational visits of Antarctic wildlife by commercial tourists and ANARE personnel.

Melissa Giese & Tamara van Polanen Petel,
Human Impacts Research Program, AAD

ANARE expeditioners take part in experiments to measure the responses of breeding Weddell seals to human visitation.
MELISSA GIESE

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RiSCCy business

Biologists sampling vegetation on Heard Island as part of the RiSCC program. Doug Thost

At the Scientific Committee on Antarctic Research (SCAR) Symposium on Antarctic Biology in Christchurch in September 1998 the Biological Investigations of Terrestrial Antarctic Ecosystems (BIOTAS) program was wound up after 15 years of international collaborative research. At that Symposium it was also decided that investigations on the impacts of global change on Antarctic and subantarctic terrestrial ecosystems and lakes should be the topic of a new international program. Thus the Regional Sensitivity to Climate Change in Terrestrial Ecosystems (RiSCC) program was born. After two planning meetings, one in Spain, the other in South Africa, the Science and Implementation Plans for the RiSCC program were developed. These were endorsed by SCAR in Tokyo 2000.

Within living memory, the Antarctic and subantarctic environments have shown marked responses to climate change. Air temperature and precipitation have changed dramatically over the last fifty years and these changes are likely to continue. Seasonal differences in the rates of temperature change have been observed on the Antarctic peninsula—autumn and winter temperatures increasing substantially more than those in spring and summer. Precipitation on subantarctic islands has declined markedly. Studies have shown direct and indirect responses by Antarctic plants and animals to these changes. The Antarctic and subantarctic provide an ideal focus for investigations on biological responses to climate change. The animals and plants that live there must cope with the changing environment and several factors make their value as research subjects precious and unique: their isolation, relative simplicity of ecosystem structure, the ease with which newly introduced organisms can be detected and that many of the organisms are living at the boundary of their range.

The principal aims of the RiSCC program are to firstly understand the interactions between the climate and the biodiversity and functioning of Antarctic terrestrial and lake ecosystems and secondly to predict regional sensitivity to the impacts of climate change. These aims will be achieved by:

(1) understanding what we currently have by identifying and quantifying differences in environments, and the biodiversity within and between ecosystems;

(2) understanding what might happen by investigating the potential for ecosystem processes to respond to changes in climate;

(3) defining which of the observed effects are due to climate change and partitioning those from the other key components of the ecosystems;

(4) using new and existing data to provide a synthesis of the likely effects of climate change on Antarctic terrestrial ecosystems to contribute to their management and conservation; and

(5) keeping in touch with others in the international scientific community who seek to understand the implications of global changes.

From the RiSCC program studies we intend to produce an 'Antarctic Environmental Gradient'. This will use data collected from a range of sites at different latitudes and altitudes and be used as a model for future climate change. This should let us predict how individual species and communities along the gradient will respond to climate-change pressures.

The RiSCC program will run for 12 years. Although it is a modern program, investigations that will be used to provide some of the historical backdrop for this program date back to the earliest surveys of Antarctic plants. We intend to coordinate old as well as recently acquired data through the Australian Antarctic Data Centre. This program is off to a flying start with several nations already undertaking RiSCC-related activities, and the fieldwork 'officially' starting in the 2000–01 summer with, among other activities, multinational investigations on Heard Island.

Harvey Marchant, Biology Program Leader, AAD

Getting a handle on Antarctic species

'Seal bearing 270 degrees, range 3km! Can anyone identify it? Is it a crabeater?' This is a typical situation on the bridge of the *Aurora Australis* in the pack ice of the Antarctic. What happens to scientific observations such as this?

The international Antarctic science program collects an amazing amount of information about wildlife. Traditionally, this information has gone into field notebooks. Bits of information are then extracted to support a scientific paper and the notebooks are filled, filed, and have often ended up as landfill.

The amount of scientific data that has been lost over the last fifty years would probably defy the imagination. It is now recognised that the data that is 'filed' in notebooks, and more lately, Excel® spreadsheets, may be far more valuable than the publications it may have supported. For the value of information to be retained, the data needs to be stored in a widely accessible repository, described and indexed. This is one aspect of the new trend called Knowledge Management: capturing information and placing it in a form so that it can be used effectively by a broad audience and for a wide range of applications.

The Australian Antarctic Data Centre (AADC) was established in 1995 to fulfil one of Australia's obligations to the Antarctic Treaty, that "*scientific observations and results from Antarctica shall be exchanged and made freely available*" (Article III.1.c). This turned out to be a farsighted undertaking as it is beginning to raise the significance of information management to Antarctic science.

Simply having a data repository by itself is of some benefit. If the clients know where the data may be found, then the effort of locating and understanding it may be rewarded. Then, along came *metadata*; a standardised description of a block of information. A library that contains ten books is easy to browse. When the library contains thousands or millions of books and journals, an index is required to locate items of interest with any efficiency. Once a data repository grows beyond a trivial size, metadata fulfils this role for clients.

As far as scientific data is concerned, the whole is more than the sum of the parts. A dataset of seal sightings for one summer is a valuable historical and scientific record. Many years of observations of a range of flora and fauna may, however, facilitate answers to questions that could not be envisaged from a more limited perspective. For example, the relationship between plants, invertebrates and environmental conditions could lead to predictions of the environmental and economic effects of climate change.

Combining similar data into a database adds value to the data by enabling a broader array of questions to be answered. The Biodiversity Database that is being developed in the AADC is just such a database. Information such as the observer, species, location, when, where, environmental conditions and a range of related data will be stored in the database. The database will be on-line on the Web for scientists to add observations to, and for *anyone* to interrogate.

The work on biological databases in the AADC started in 1995 when all known breeding locations of Antarctic penguins were placed into a database and enabled for Web searching on http://aadc-db.aad.gov.au/pls/dataaccess/fauna_search. Scanning a book containing these locations for information that you may need is far less flexible than searching the database. With the database, information can be searched by species, observation date and time, location, number of individuals and type and accuracy of survey. Over the past four years, many additional sightings of Antarctic birds and seals have been entered into this database.

A flora database was also constructed in 1996. The AADC recognised that the flora and fauna databases contained similar entries; a species was observed by someone at a particular time and location that had certain environmental characteristics. In 2000, the international science project called Regional Sensitivity to Climate Change (see previous article) was initiated. Scientists working on the RiSCC project wanted to be able to ask questions that related to any aspect of biological and environmental observations. The Biodiversity Database was born.

Observations of flora and fauna collected by the science programs of all Antarctic Treaty countries will be entered into the Biodiversity Database. The database will be publicly available on the Web to search, and to download any subset of observations.

Now, the single observation taken on the bridge of an icebreaker, or anywhere in the Antarctic, will hopefully result in a record of a species occurrence being entered to the Biodiversity Database. Who knows what information, knowledge and wisdom may then emerge!

Lee Belbin, Australian Antarctic Data Centre Manager, AAD.

Searching for seabirds from the bridge wing of Polar Bird ERIC WOEHLER

Maps are more than just a pretty picture: science and the new mapping technologies

Australia has been involved in mapping of the Antarctic continent since the start of exploration there at the turn of the 20th century. Even in those days maps were used as a scientific tool to integrate and visualise data. The first maps published were as attachments to reports and scientific journals such as those presented to the Royal Geographical Society in London. Printed maps continued to be the major end product of the ANARE Mapping Program until as recently as the early 1990s. However, with the advent of Geographic Information Systems (GIS), the hard copy map is now only one of many purposes for which survey information is used. Topographic information is the foundation for the GIS but the software facilitates spatial analysis and visualisation in addition to the efficient production of maps.

The ability of GIS to rapidly overlay data from different sources makes it a powerful tool that is now being used to support a wide array of Australian environmental, scientific and operational activities in the Antarctic and Subantarctic.

In the 2000-2001 season, surveyors have been involved with mapping in support of scientific and logistic programs at Heard Island, Windmill Islands, Vestfold Hills, Larsemann Hills and Macquarie Island.

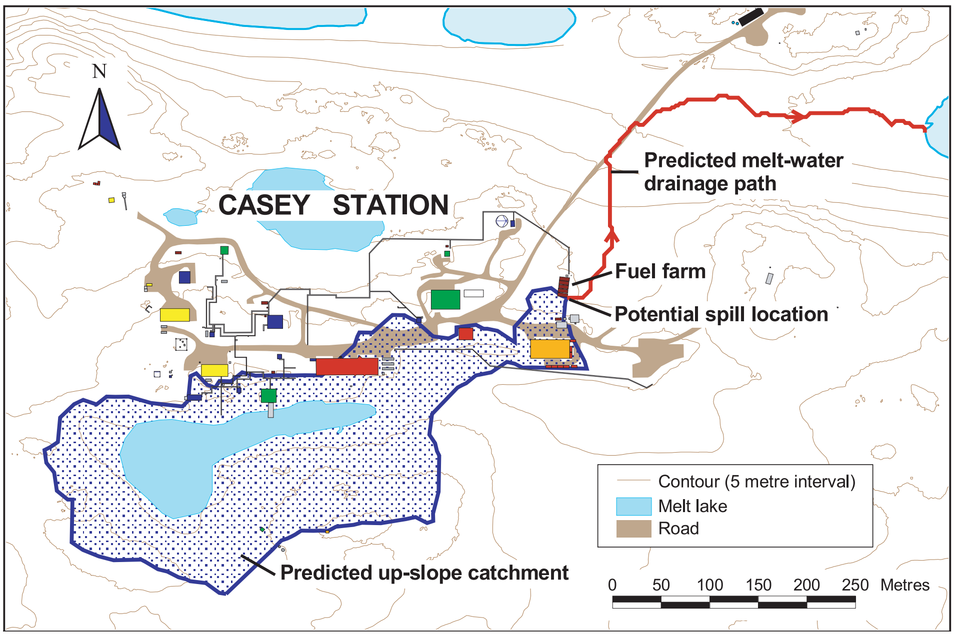
At Heard Island, aerial photography has been used for the census of seals and penguins, for mapping of vegetation and to provide detailed surveys for archaeologists. Aerial photographs from this season will be compared with those from 1985 to determine whether there have been changes in the sizes of glaciers or vegetation cover that could be attributed to global climate change during this period.

At Casey, the GIS is being using to assist with clean-up and management of the abandoned waste disposal sites at Thala Valley and will later be used at the nearby Wilkes Station. This project will take many years to complete and one of the priorities for ensuring success is to carefully document all aspects of investigation, clean-up and subsequent remediation. The GIS has been used to calculate quantities of material that should be removed, to model the flow of melt-water through the site so this can be controlled, and to interpolate the likely distribution of contaminants from point samples. As the project moves into the operational phase the GIS will be used to visualise progress on site so that the clean-up can be managed remotely from Australia.

Surveying was one of the major activities of the first scientific expeditions to Antarctica—and is still an essential component of much research. The new technologies such as the Global Position System, GIS and remote sensing from satellites, allow spatial information to be captured much more efficiently. As a consequence, tasks that would have been totally impractical only a few years ago are now feasible. The entire continent of Antarctica can now be mapped at a small scale in a matter of weeks. To detect changes over time surveys can be repeated at intervals that would have been inconceivable ten years ago. Using GIS, maps can be generated in the field by scientists so that data can be immediately checked, and if necessary repeat observations can be achieved. *Henk Brolsma, Mapping Officer, AAD.*

Modelling for Oil Spills

The GIS has been used to set up, for each ANARE station, a tool that allows the user to interactively specify a location and then view two types of information that are important for managing an oil spill:
(i) the predicted melt-water drainage path from that location; and
(ii) the predicted up-slope catchment contributing drainage to that location.



Australian Antarctic Data Centre

Australian Antarctic Data Centre

Clockwise from top left: Satellite image map of the Larsemann Hills; total workstation at Atlas Cove, Heard Island, with Australia's highest active volcanoe, Big Ben (2760 m), in the background; an aerial photograph of Mawson Station; a scientist using real time GPS to log GIS data in the Stillwell Hills; and a map produced from the GIS of Laurens Peninsula, Heard Island.

The Australian Antarctic Division Map Catalogue

The Australian Antarctic Division holds a collection of approximately 3,500 maps and charts. In 1998 the Australian Antarctic Data Centre began the task of collating a catalogue of its holdings. After several previous attempts to complete this large task, the Map Catalogue was published online in early 1999.

The Map Catalogue includes:

- Historical maps dating back to the mid 1800's
- Thematic maps such as geological, vegetation and bathymetry maps
- Hydrographic charts
- Topographical maps
- Satellite image maps
- Orthophoto maps

Many countries from around the world distribute their Antarctic maps and charts through an agreement by the Scientific Committee of Antarctic Research (SCAR). These are also included in the Map Catalogue. The Australian Antarctic Division online Map Catalogue was recently adopted by the SCAR Working Group on Geodesy and Geographic Information as the international standard for the cataloguing of Antarctic maps.

Ursula Ryan, GIS Officer, AAD.

Antarctica Online

Electronic, interactive and datasets suitable for use in a GIS, can be viewed and downloaded at the Australian Antarctic Data Centre (AADC) web site at: http://www-aadc.aad.gov.au.

Thumbnails and details of hard copy maps can be viewed at: http://www-aadc.aad.gov.au/mapping/aadmaps.asp

Hard copy maps can be purchased through AUSLIG Map Sales Centres. A list of these centres is available at: http://www.auslig.gov.au/products/maps/mpretail.htm

Selection of Antarctic maps: http://www-aadc.aad.gov.au/gis/maps/

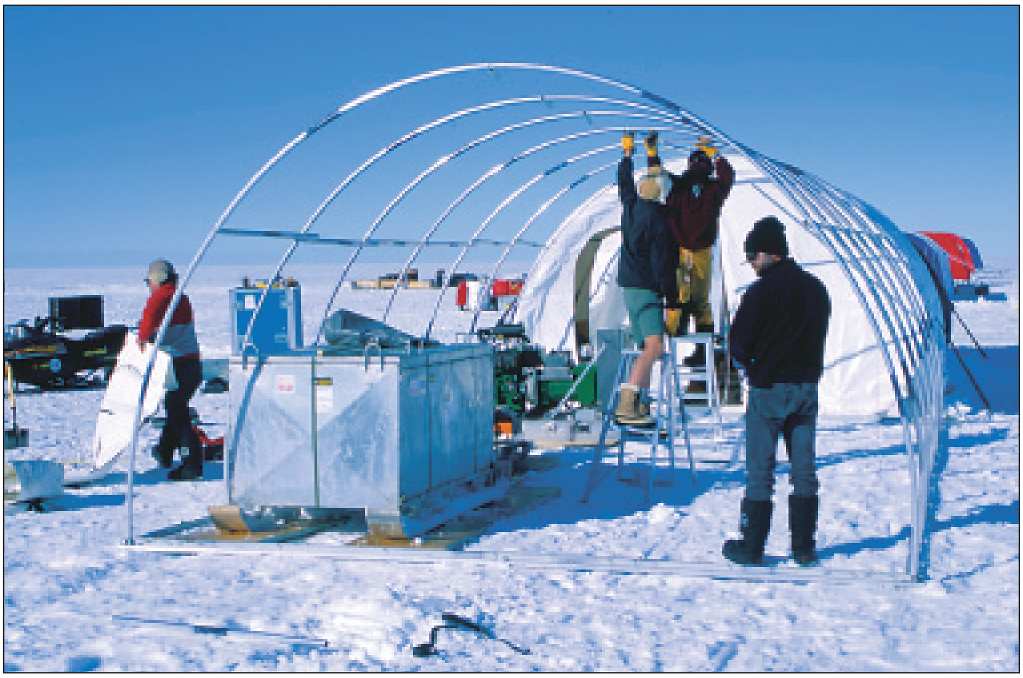
All digital and interactive maps: http://www-aadc.aad.gov.au/gis/areamap/

Download of digital data: http://aadc-db.aad.gov.au/pls/logon/reg_files

Search for data: http://aadc-db.aad.gov.au/cgi-bin/zgatedriver.pl

Peephole through the ice: the AMISOR project

The Amery Ice Shelf Ocean Research (AMISOR) project is a new multi-year research project of the Australian Antarctic Division and the Antarctic CRC which aims to investigate the interaction between the Amery Ice Shelf and the ocean. The project will provide an assessment of the role of the Amery Ice Shelf in the ice sheet mass budget, and in driving deep ocean circulation.



Assembling a plant and equipment shelter for the AMISOR hot water drill this summer. Large unit at front is the air compressor for purging water from the system after drilling. Mike Craven

Floating ice shelves, which fringe the Antarctic continent, are the main pathway for ice loss from the ice sheet, either via iceberg calving from their outer margins or as basal melting in the ocean cavities beneath. The Amery Ice Shelf, the largest in East Antarctica, drains the Lambert Glacier–Amery Ice Shelf system, which accounts for 16% of the area of the grounded East Antarctic ice sheet.

Melt and refreezing processes on the underside of the floating shelves can be significant, but are poorly understood. As much as 50% of the total ice draining from the Lambert Glacier system is lost as melt beneath the Amery. The modification of ocean water properties that results from melting and freezing processes under ice shelves may be important in the formation of Antarctic Bottom Water, and hence critical in global ocean circulation.

Ice shelves are always thickest (800 m or more) closest to the point where they are joined to the grounded continental ice, and thinnest (~250 m) at their seaward front. The freezing point of sea water decreases with pressure, so as cold salty ocean water flows under an ice shelf it can come into contact with the shelf ice at a depth where it is above the local freezing point, and hence cause melt. This melt freshens the seawater and makes it more buoyant so that is rises again along the sloping underside of the ice shelf. Eventually it will reach a point where it is once more below the freezing point, and new ice crystals are nucleated and may adhere to the underside of the ice shelf in a layer known as 'marine ice'. (Figure 1)

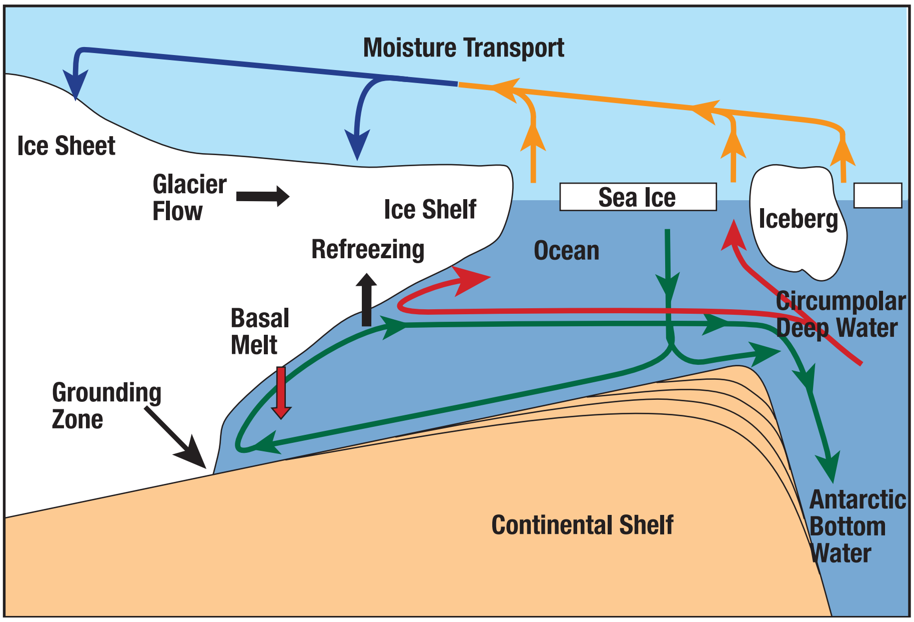


Figure 1: *Schematic representation of the 2-D circulation under an ice shelf. Salt rejected by winter sea ice growth forms dense, high salinity water, which sinks and flows under the ice shelf. This causes melt when it comes into contact with deep ice. The freshened plume rises under the base of the shelf and can either refreeze as marine ice or mix with warm salty Circumpolar Deep Water to form Antarctic Bottom Water.*

There is also a horizontal pattern to the distribution of melting and freezing under the ice shelf, linked to the clockwise ocean circulation. Recent work at the Antarctic CRC by Helen Fricker has delineated the distribution of marine ice from satellite radar altimeter data, and ice thickness soundings. In places the accreted marine ice is almost 200 m thick (Figure 2).

The AMISOR project aims to better quantify these processes through both an oceanographic component and a shore component. The oceanographic component, led by Nathan Bindoff of the CRC, will make detailed measurements across the front of the Amery Ice Shelf of the characteristics and flow of the seawater entering and leaving the ocean cavity beneath the shelf. The first phase of these measurements will be made from RSV *Aurora Australis* during voyage 6 of 2000/01. Moored instruments will be left in situ to continue measurements over a full annual cycle.

The shore component of AMISOR will make *in situ* measurements of the processes beneath the shelf through a series of access holes drilled completely through the shelf. These holes are to be made using a new hot water drilling facility designed and constructed within the AAD. The drilling party, led by Mike Craven, was deployed on the Amery in mid December 2000, and on New Year's Eve successfully penetrated through 380 m of ice into the ocean cavity. Once the drill facility was assembled and tested it took only 24 hours to sink the 300 mm diameter borehole using a high-pressure jet of hot water. The hole was subsequently reamed to 400 mm diameter and a series of measurements made in the ocean beneath the shelf. These show that the top 40 m of the 440 m deep cavity beneath the shelf is a relatively fresh layer derived from basal melt under the shelf. Some instruments have been left in the borehole to continue measurements over several years.

Further measurements in this and subsequent boreholes, combined with the oceanographic data from the front of the shelf, will provide estimates of the amount and distribution of melt and freezing under the shelf, and will be used to validate numerical models of the ocean circulation in the cavity being developed by John Hunter, Roland Warner and colleagues.

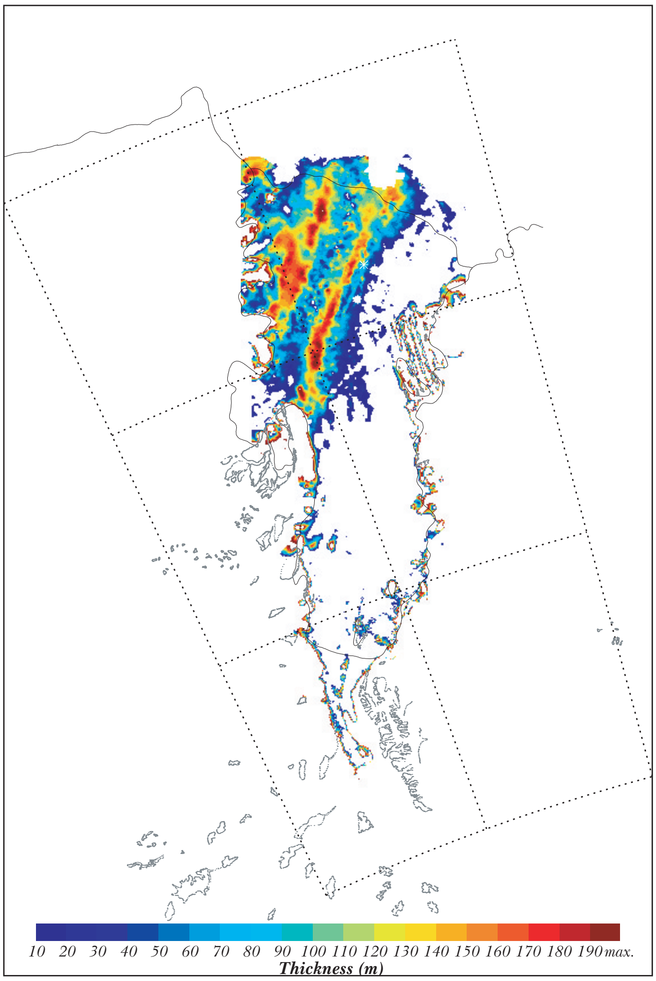


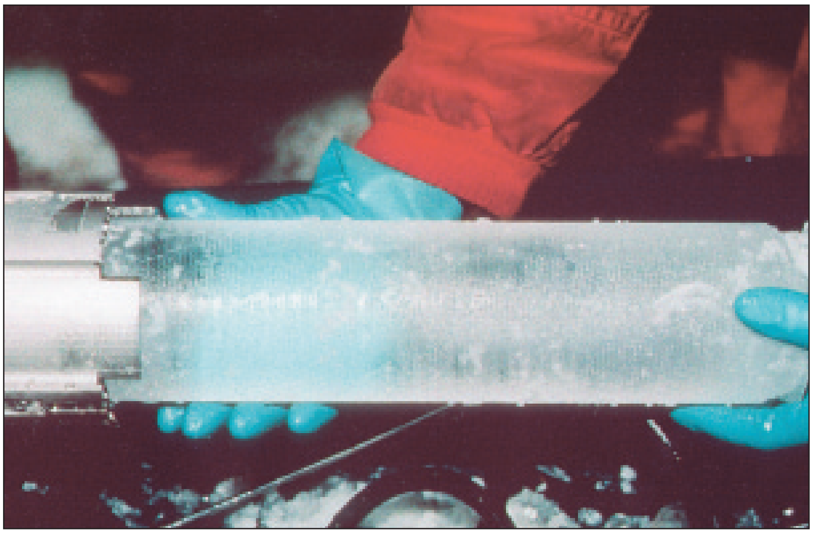
Figure 2: *The thickness (in metres) of accreted marine ice underneath the Amery Ice Shelf.*

The hose reel and motor controller of the AMISOR hot water drill showing crimping tool for hose fittings. Mike Craven

Ian Allison,
Glaciology Program Leader, AAD

Volcanic eruptions and solar activity detected in ice core

The deep ice core extracted from Dome Summit South (DSS) at Law Dome (120 km from Casey station) provides a climatic and environmental record extending back over eighty thousand years, well into the last ice age. The DSS drill site has a very high snow accumulation rate by polar standards (equal to approximately 64 cm of water per year), making the record particularly detailed.



The deepest ice core (1200 metres) extracted from the DSS site. Vin Morgan

Recent analysis of trace chemicals in the ice at approximately monthly resolution has provided precise timing of more than a dozen major global volcanic events over the past 700 years, and also revealed subtle signals of 17 solar events in the past 112 years.

Solar activity and volcanic eruptions both are natural mechanisms for climate. Proxies of these, such as the ice core chemical markers described here, are important keys for understanding how much of the observed climate variations today are attributable to human influence.

Volcanic signal

Major volcanic eruptions eject large quantities of dust and fine aerosols into the atmosphere. Some of the aerosols find their way into the stratosphere where they can persist for several years, producing the spectacular sunsets familiar to many following the Mt Pinatubo eruption in 1991. These aerosols influence climate by reducing the amount of sunlight that reaches the Earth's surface. Eventually, depending on the location of the eruption and prevailing atmospheric conditions, the chemicals from the aerosols (principally sulphate) find their way into precipitation, increasing the acidity slightly. It is this increase in sulphate levels that can be detected in the ice core.

Drilling operations at the DSS site. Vin Morgan

The Law Dome ice core shows that the lag between eruptions and the arrival of detectable fallout varies from 10 months to 2.5 years for 10 well-dated eruptions. It also shows a very large eruption in about 1459 (the largest sulphate producer in the 700-year record). An event around this time had been recorded in other ice cores, but with less precision. Historical and tree-ring records, suggested an event in 1453 which is thought to be the eruption of the volcano Kuwae in Vanuatu. Even with the variation in transport time and general dating uncertainties, the DSS ice core signal cannot be made to match an eruption much earlier than 1456, and so an interesting puzzle is emerging. The matter is of more than academic interest, because large events like this tend to be used to tie the dating in records from a wide range of sources.

Solar signal

The solar activity signal in the DSS core shows as increases in nitrate following solar outbursts called solar proton events. Nitrate is one of the more poorly understood major atmospheric chemicals, but theoretical calculations have pointed to the potential for production by solar proton events. In fact, some ice core studies have reported large nitrate spikes, which have been tied to solar events, but other studies have failed to find any connection at all. The Law Dome result is significant because it uses the good dating control in this core to search for, and detect, nitrate elevation following 17 known solar events.

Tas van Ommen & Vin Morgan,
Glaciology Program, AAD

Do buoys have all the fun? The Mertz Glacier polyna experiment

(left) MetOcean bouy is deployed by helicopter.

(left bottom) HiHo bouy in position. Flags enable visual identification of bouy's position in the future. Victoria Lytle

During an 8 week winter voyage in 1999, the RV *Aurora Australis* worked in one of the active ice forming areas, known as polynyas, right on the Antarctic coast. Paradoxically, although these areas are relatively ice free, they are areas of very high ice production. When open water occurs near Antarctica in winter, the loss of heat from the ocean to the cold polar atmosphere is enormous, and ice production is consequently very rapid. Salt is rejected from the growing ice into the underlying ocean, increasing its density, and these processes within polynyas are potentially a vital first step in the formation of the cold, dense Antarctic Bottom Water. Strong winds constantly push the ice away from the coast, allowing the open water to persist.

Although this is not the first research cruise to the Antarctic pack ice in winter (there have been several in other parts of Antarctica, and one earlier ANARE expedition to the more northerly pack ice south of Australia in 1995) it is the first time that a vessel has worked in a polynya, right on the Antarctic coast during winter. The 62 scientists and technicians on the ship spent nearly six weeks within the sea ice zone, investigating oceanographic and glaciological processes that are related to global climate, and undertaking a range of biological studies. This article describes only a small part of the larger experiment.

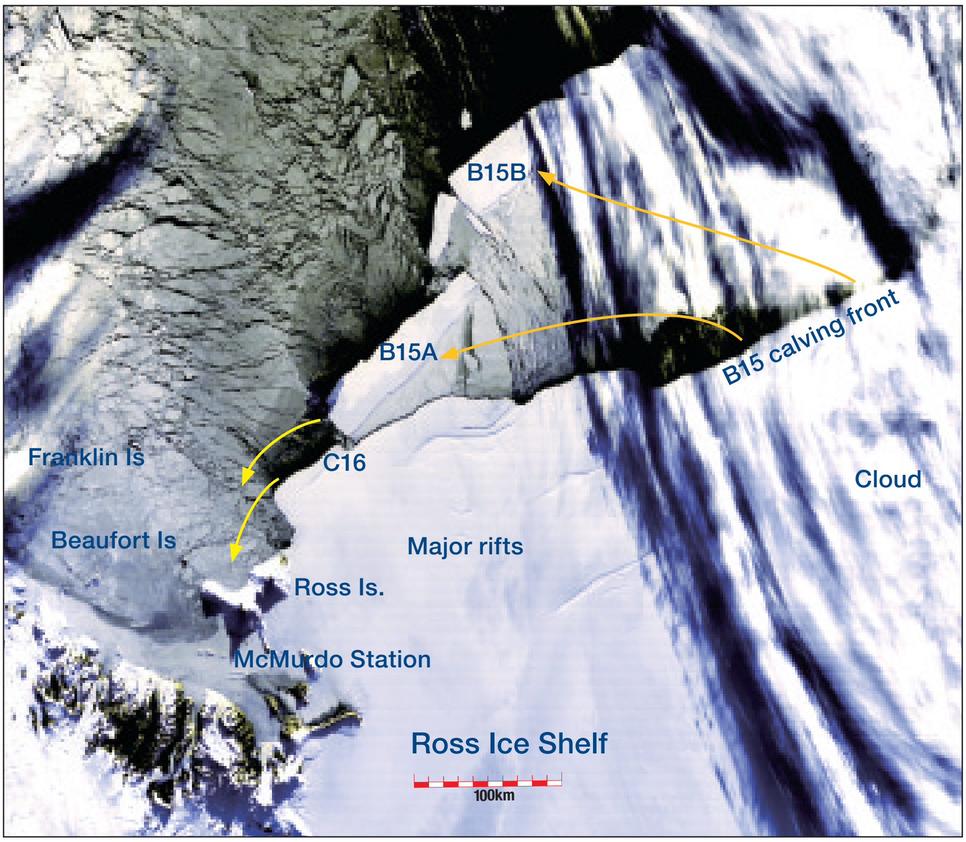
How much ice grows in the polynya? Where does the ice go? What is the deformation rate? These were just a few of the questions the Glaciology Program hoped to answer. We deployed 21 buoys in total, which sent back hourly GPS positions that were plotted on a chart. Three types of buoys were used depending on the ice conditions, and the desired lifetime of the buoy. Fifteen small lightweight buoys were deployed on thin and newly forming ice in 3 sets, approximately one week apart. We revisited them during the experiment to measure how much ice had formed since deployment. One lasted only five days, probably buried in the heavy, deformed ice to the west of the polynya, while another meandered northwest to the ice edge, sending data back for over two months.

Three MetOcean buoys were deployed to measure the strain and drift rate of the thicker ice to the north of the polynya. This information is needed for some of the regional scale models of polynyas. The MetOcean buoys are the largest drifters, designed to last for more than a season. This type of buoy is routinely deployed from our ships to track the drift of the sea ice. Three 'HiHo' buoys were also deployed on the thicker ice to the north of the polynya, to augment the MetOcean buoys and provide increased data on ice strain rates. These in-house designed buoys were also used in a 1995 experiment. The large round red saucer-shaped buoys were deployed using either the ship's crane or slung under the helicopter. Two of these sent back their positions for the design lifetime of about three months. With speeds up to 3 km/hr, very little daylight, and at times very thick ice, finding all twenty one buoys again to measure the amount of ice which had formed was a challenge, although not impossible.

The ability to track the ice as it formed has provided a wealth of information on ice growth rates, the importance of deformation in new ice formation, and the different drift rates of different ice thickness.

Victoria Lytle, Glaciology Program, AAD

An iceberg the size of Jamaica!



A satellite image of the Ross Sea and Ross Ice Shelf acquired by the MODIS instrument on NASA's TERRA satellite on 21 September 2000. Several sections of the massive iceberg B15, which calved in March 2000, are visible. The orange arrows show their approximate drift tracks away and along the ice shelf front. Cloud partly obscures the ice shelf and some icebergs to the east. The US Antarctic station, McMurdo, is located on the south west corner of Ross Island at the southern end of McMurdo Sound. Beaufort Island is about 23 km from Cape Bird, and Franklin Is another 100 km further north. The section of ice shelf labled C16 (15 km x 43 km) calved a few days later and has since drifted up to Ross Island, near Cape Bird, with B15A (35 km x 161 km) following in behind to Cape Crozier at the eastern end of the island (yellow arrows). Depending on their future drift and the time they remain in the area these two icebergs could have a major impact on the distribution and movement of sea ice, and thus on wildlife, such as the emperor penguins of Cape Crozier, or shipping access to McMurdo Sound. The remainder of the icebergs are drifting slowly north west across the Ross Sea towards Cape Adare from where they are likely to head west around the coast.
Data provided by NASA/GSFC/DAAC. Image produced by Glenn Hyland, Antarctic CRC.

Several immense Antarctic icebergs calved from Ross Ice Shelf in the Ross Sea sector, and from Ronne Ice Shelf in the Weddell Sea sector during 2000. Those icebergs are now slowly drifting around and away from the continent. The first of these events, in March 2000, produced iceberg B15, the largest ever observed. When it calved, it was approximately 295 km long by 37 km wide, with an area of about 10,600 km^2. On the other side of the continent, two immense icebergs calved from the Ronne Ice Shelf: A43 (250 km by 34 km), and A44 (60 km by 32 km). Since then, further events on Ross Ice Shelf have led to the calving of icebergs B16, B17, B18, B19, and C16. Altogether, ice has calved from more than 65% of the 750 km length of the front of Ross Ice Shelf, and a similar proportion for Ronne Ice Shelf.

The icebergs receive their names from the (US) National Ice Center (NIC). The NIC records and follows the drift of any iceberg greater than ten nautical miles in length. The nomenclature they use divides the Antarctic region into four quadrants, each designated by a letter from A to D. The 'A' quadrant is from the Greenwich meridian of longitude (0°E) to 90°W, and spans the Atlantic sector, including the Weddell Sea. Quadrant B is from 90°W to 180°E, C from 180°E to 90°E, and D from 90°E to 0°E. Each iceberg is designated by the letter corresponding to the sector in which it is first sighted, which is usually where it is formed, and a number which is next in sequence for the sector. So B15 is the 15th iceberg identified by the NIC in the 'B' sector. When one of the tracked icebergs splits into two or more sections, each daughter iceberg greater than 10 nm long is designated by the name of the parent iceberg and an additional letter. Over the time since its calving, B15 has broken into six sections, B15A, B15B, to B15F. Ross Ice Shelf spans the boundary between sectors 'B' and 'C' and thus one iceberg which calved from the western end is named 'C16'.

The calving of icebergs, even of the size of B15, is a natural consequence of the development of an ice shelf. Snow which has fallen on the surface of the Antarctic ice sheet compacts and forms ice as further snow accumulates on top. The ice gradually flows outwards till it crosses the grounding line, the boundary between the grounded ice and floating ice. Along large sections of the grounding line, this ice flows into floating ice shelves. Ice is lost from the ice sheet by calving of icebergs from the outer perimeter and by melting from the basal surface of ice shelves and glaciers. The rate of loss roughly balances the input of snow to the surface.

In satellite images, rifts in Ross Ice Shelf are seen tens and even hundreds of kilometres inland from the outer margin, and running parallel to the margin. These rifts typically develop and extend over many years till an iceberg breaks off. The rifts which formed the 'calving front' for B15 could be clearly seen in images acquired by the Canadian Radarsat in September 1997 over a length of about 240 km. The precursors to these rifts were identifiable in Landsat images acquired many years before this. The calving of B15 could thus be anticipated, but the actual timing of such events is very difficult if not impossible to predict.

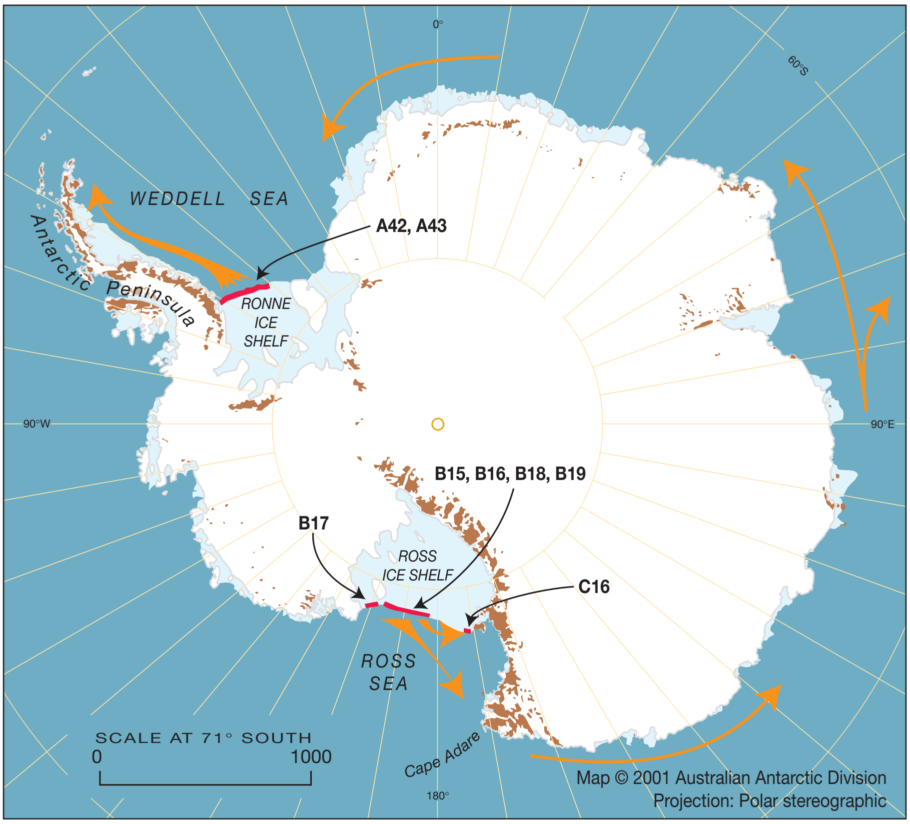
The total area of ice shelf lost during the year 2000 by the various calving events from Ross Ice Shelf and Ronne Ice Shelf is about 23,000 km^2, or around 1.5% of the area of all ice shelves around Antarctica. The total volume of water contained in just those icebergs is over 5,000 Giga-tonnes, more than twice the estimated annual turnover of ice for the whole Antarctic continent. This is equivalent to sufficient water to supply all of the world's water needs, agricultural, industrial, and domestic, for more than a year. The estimated annual average accumulation of snow on the ice sheet, and therefore average annual turnover of ice, is around 2,500 Gt.

While the scale of these events and the volumes are immense, the calving of this many very large icebergs is believed to be the consequence of a natural progression of events that occur in ice shelves, and quite unrelated to 'Global warming' or 'Greenhouse' effects. Mean annual air temperatures at the ice shelf fronts, between latitudes of 75°S and 78°S, are around -20°C, and summer air temperatures rarely reach melting point. Ocean temperatures are at, or close to, freezing throughout the year. Calving of ice from any section of the front of an ice shelf may occur frequently and produce a few or many small icebergs, or occur rarely and produce one or a few very large icebergs. Typical period of calving for a section of Ross or Ronne Ice Shelf appears to be around several decades. For the whole of Antarctica, very large icebergs with a length of several tens of kilometres can be expected to be produced several times a decade.

By way of contrast to these 'normal' events, there has been a dramatic descrease in the area of relatively small ice shelves fringing the Antarctic Peninsula over several decades, and the disintegration of the northern-most section of Larsen Ice Shelf (Larsen 'A', at latitude 65°S) in January 1995. These changes have accompanied a warming of several degrees observed since the 1940s in the Peninsula region, with mean summer temperatures approaching 0°C, and significant melt water production on the surface of many of the ice shelves. Re-freezing in crevasses of melt-water runoff has progressively weakened the structure of those shelves.

There is much to be learnt from observing these calving events and the evolution of the resulting icebergs. Information about the fracture processes that contribute to the calving of icebergs is required for incorporation into computer models of the ice shelves in order to assess their future development. Observing the drift of the icebergs gives information on the ocean currents with which they move. Observations of their breakage and melt rates as they drift into progressively warmer waters provides information on the probable impact on the ice shelves of warmer temperatures in the air or polar waters accompanying a climate change.

Neal Young, Glaciology & Remote Sensing, Continental Ice Sheet Program, Antarctic CRC & AAD



PETER BOYER

Map of Antarctica showing sections that calved in 2000 from the fronts of Ross Ice Shelf and Ronne Ice Shelf. Arrows indicate approximate current and predicted drift tracks of those icebergs. The Ross Ice Shelf icebergs, are likely to follow a path similar to another large iceberg, B9, that calved from the eastern end of Ross Ice Shelf in 1987. B9A has already drifted round the coast to Weddell Sea. It spent many years grounded near the Antarctic coast. B9B, the largest section of B9, is still grounded close to Mertz Glacier. B16, the first of the new icebergs to drift out of the Ross Sea past Cape Adare, is now heading west round the coast.

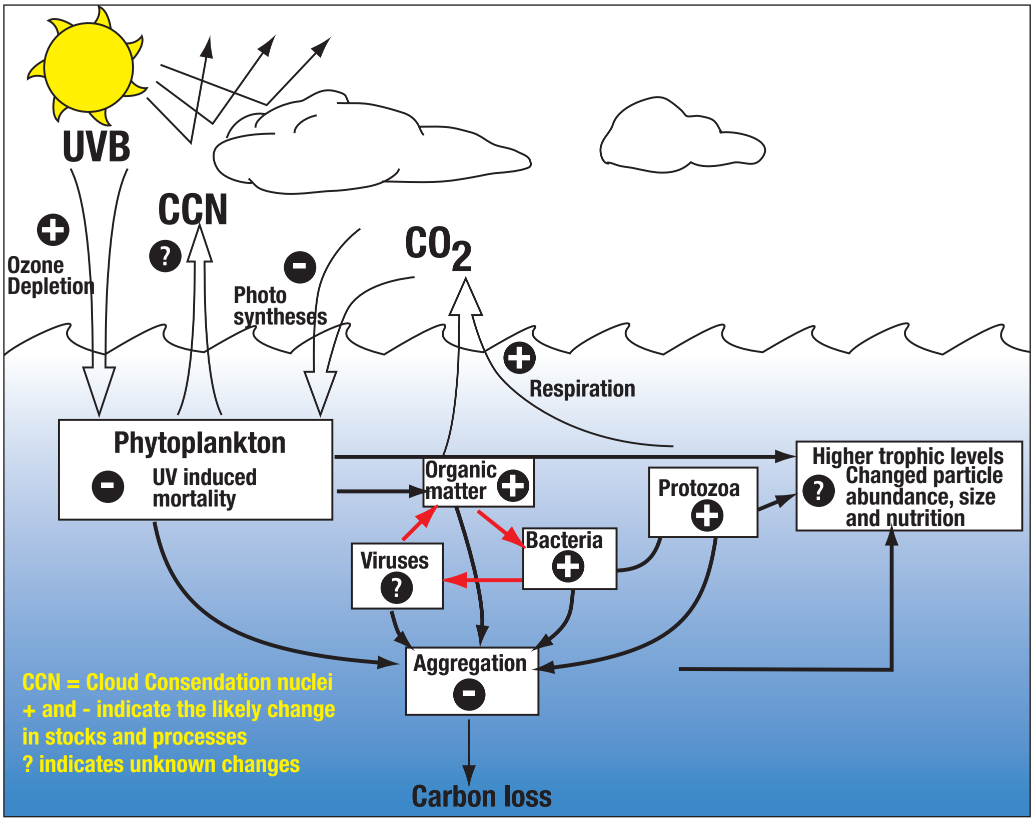
Effect of ozone depletion on Antarctic marine microbes

Single celled marine plants (phytoplankton) are instrumental in determining global climate. They moderate the global greenhouse effect by absorbing CO_2 from the atmosphere and they release sulphur compounds, which when vented to the atmosphere, promote cloud formation and increase global reflectance of the Sun's rays. Phytoplankton proliferate in Antarctic coastal waters during spring and summer where, directly or indirectly, they support the wealth of marine life for which Antarctica is renown. Single celled animals (protozoa), bacteria and viruses consume most of the energy trapped by phytoplankton (see diagram).

Depletion of stratospheric ozone over Antarctica during spring and summer increases solar ultraviolet-B (UVB, 280-320 nm) radiation throughout the period of greatest biological production. There is overwhelming scientific evidence that UVB penetrates to biologically significant depths in the marine environment and is damaging to marine organisms. Previous studies of the effect of UVB have concentrated on phytoplankton. But phytoplankton do not exist in isolation and other microbes, the protozoa, bacteria and viruses, can be directly damaged or killed by solar UVB. Due to the interactions between trophic levels of the microbial community, any UVB-induced impact at one level can alter the entire community. To understand the total effect of UVB, we need to consider both the effects on each species and those on the whole community.

We exposed natural Antarctic microbial communities to ambient sunlight in incubation tanks at Davis station. Responses of the individual species of microbes to UV exposure varied from increased growth to mortality. However, near-surface UVB irradiances caused an overall decline in phytoplankton concentration and biomass. This UVB-induced phytoplankton mortality promoted bacterial activity and these bacteria, possibly together with the material from dead phytoplankton, fuelled growth of protozoa that were UV-tolerant. This study showed that exposure to UVB can caused a complex mosaic of changes in the microbial community. Different species of microbes exhibit differing sensitivity to UVB exposure. The extent of these changes was determined by the direct effect of UVB on the microbial species, and the indirect effect of UVB-induced changes on the microbial community. We concluded that exposure to UVB radiation can change the abundance, size, structure, palatability and nutritional quality of food within the food web. Results indicate that UVB radiation can change the structure and function of the microbial community, reducing the uptake of CO_2 by phytoplankton and increasing the CO_2 respired by microbes (see figure 1). Thus, ozone depletion is likely to reduce the capacity of Antarctic waters to act as a sink for atmospheric CO_2, and exacerbate global climate change due to 'greenhouse' warming.

Andrew Davidson, Biology Program, AAD



Schematic diagram indicates the result of ozone depletion of marine microbes and the resulting impact on global climate.

TIGER eyes look south for space weather

A view of the TIGER radar on South Bruny Island, showing the main array of sixteen transmit/receive antennas and the sub array of four receiving antennas. DANNY RATCLIFFE

THE TASMAN INTERNATIONAL GEOSPACE ENVIRONMENT Radar (TIGER) is an Australian initiative to study the Earth's geospace environment in order to extend our scientific knowledge and improve space weather predictions. TIGER will consist of two High Frequency radars, one in Tasmania and one in New Zealand, with intersecting beams looking toward Antarctica. The radars will survey the ionosphere, providing measurements on the behaviour and characteristics of aurora and other phenomena. TIGER will operate as a stand-alone radar but will also be part of SuperDARN (Super Dual Auroral Radar Network), an expanding international network of radars being established to provide coverage of northern and southern hemisphere high-latitudes. TIGER's specific location at a lower latitude than other radars in the network, will enable it to make unique contributions to the international program.

Geospace and space weather

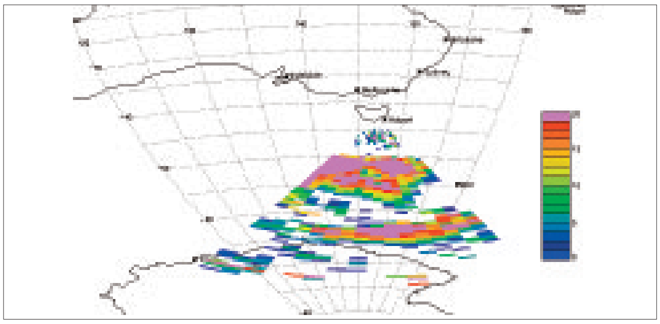
The solar wind consists of ionised particles, streaming outwards from the sun at ~300–800 km/s and carries with it the Interplanetary Magnetic Field (IMF). Earth's magnetic field acts as a barrier to the IMF and solar wind particles. As the solar wind streams past Earth, the terrestrial magnetic field is compressed on the dayside and extended on the nightside, giving the magnetosphere (the region of influence of Earth's magnetic field) a comet-like shape. Geospace is the near-Earth space environment consisting of the ionosphere, magnetosphere, and nearby solar wind. It is a vast region extending from about 50 km altitude to geocentric distances in excess of a million km. Like weather on Earth, that in the ionosphere—the region between 100 and 800 km above Earth's surface where satellites operate—is changeable. There can be winds up to 1 km/s, variations in temperature of more than 100°C and changes in atmospheric composition. Most extreme ionospheric events are caused by the sun ejecting large amounts of matter in Coronal Mass Ejections (CMEs) and solar flares.

When CMEs are directed towards the Earth, they cause large magnetic storms that greatly affect the magnetosphere, ionosphere and thermosphere, producing spectacular auroral displays at locations where the aurora is rarely seen. The varying conditions of geospace, including these dramatic storm effects, are referred to as space weather.

Accurate space weather predictions are of increasing economic importance because of the deleterious effects caused by magnetic storms on such devices as communication and Earth resource satellites, and electric power grids. Forecasting such storms, or 'nowcasting'—informing appropriate authorities that a space storm has started—may enable them to switch off or change to backup systems. Also, high space winds increase drag on satellites in space, causing them to slow and change orbit. Unless low-altitude Earth-orbit satellites are routinely boosted in height they fall slowly and eventually burn up in the Earth's atmosphere.

Auroras are the only sign of space weather visible to the naked eye from Earth. They are geomagnetic storms in which electrons and ions enter Earth's atmosphere near the poles striking molecules and atoms in the high atmosphere, causing them to glow in different colours. Some aspects of space weather, including magnetic storms, affect much of modern technology. Magnetic storms can disrupt many communications systems which use the ionosphere to reflect radio signals. The same applies to sea and air navigation systems.

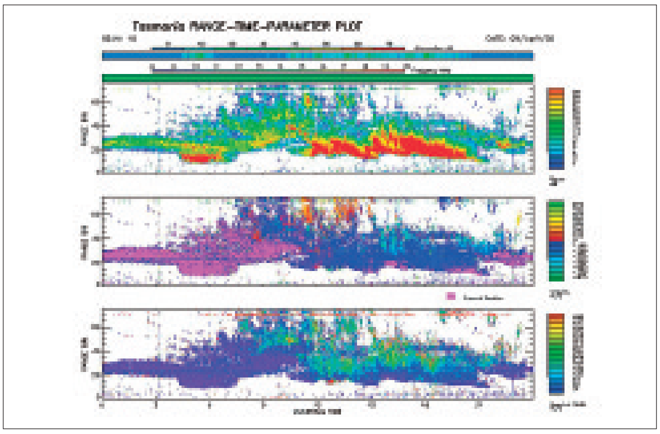
Geologists searching for oil, gas or mineral deposits use the Earth's magnetic field to find subterranean rock structures—but can only do so when the Earth's field is quiet. Knowledge of when storms abate, or are about to start, therefore has commercial implications.



A radar sweep, showing the radar footprint and the sixteen beams.

Another relevant area of commercial importance is electricity transmission. During geomagnetic storms, magnetic fields interact with such conductors as wire, and induce an almost direct electric current. Thus they interfere with alternating current in power transmission lines and cause harm to equipment. A warning of the approach of a geomagnetic storm, or even drawing attention to its presence, enables power companies to switch off or transfer power.

Other potential uses include medicine, as there is accumulating evidence that changes in the geomagnetic field affect biological systems. High-energy charged particles emitted during major bursts of solar activity are potentially lethal to space travellers, either in Earth orbit or on future interplanetary missions, and can also expose passengers on commercial jets at high latitudes to increased radiation levels. The list of beneficial consequences of knowledge about space weather grows in proportion to humanity's dependence on technology, making the work of TIGER more important with time.



A daily plot from the radar, showing the location and velocity of ionospheric features over the course of a day.

How does TIGER work?

TIGER is an over-the-horizon radar, which transmits radio waves that are refracted by the ionosphere. A small amount of the radiated energy is backscattered by irregularities in the ionospheric plasma and is received back on the ground by the radar. The transmitting antenna consists of an array of 16 log-periodic antennas that form a narrow beam that is swept across the radar footprint in 16 steps. An additional four antennas placed behind the transmitting array are used to form an interferometer receiving array that measures the elevation angle of echoes. Subsequent processing and analysis gives us information on the velocity of the ionospheric plasma. Convection flows over a large region can be measured every 90 seconds. Velocity maps determined from TIGER provide an 'instantaneous' or 'real-time' picture of the convection of the plasma in the ionosphere and magnetosphere. Convection is the primary response of the magnetosphere to variations in parameters of the interplanetary medium, and to the coupling processes at the interface between the magnetosphere and the solar wind.

TIGER science program

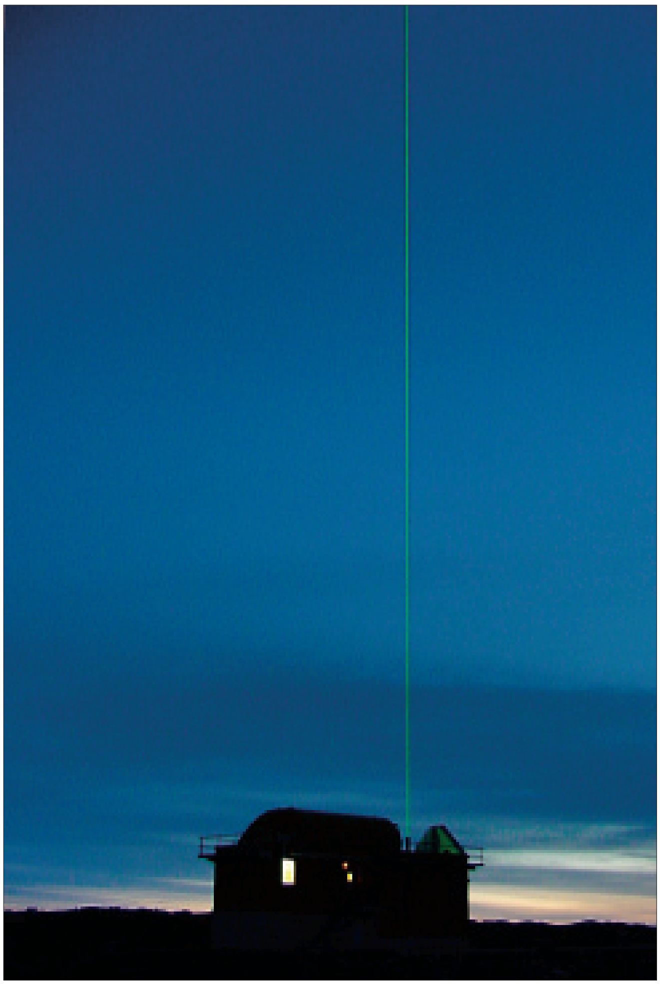
The first of the TIGER radars is located on South Bruny Island and probes the ionosphere over an area approximately the size of Australia between Hobart and Antarctica. In the simplest terms, the radar determines the location of aurora and other phenomena in the high-latitude ionosphere, and measures the associated flow patterns. Hence it enables the driving forces, which include both magnetospheric and ionospheric processes, to be studied. The wide coverage of the radar also enables the propagation of effects to lower latitudes to be studied and this is particularly important for practical applications relevant to Australia. Basic research programs will be carried out to understand the fundamental processes involved, and applied research will be conducted to develop methods of predicting the impact of the various phenomena on the performance of over-the-horizon radar, communication circuits, and satellite operation.

TIGER is in an ideal location to study the expansion of the auroral phenomenon to lower latitudes that takes place during large magnetic storms. Sunspot activity is expected to peak during 2000–01 and large magnetic storms can be expected during the next two years.

The SuperDARN radar array will provide an ideal diagnostic for other experiments located at the Australian Antarctic stations, Macquarie Island and within Australia. Overall the TIGER radar will be a facility of international standing in the study of Geospace and it will ensure that Australia continues to play a leading role in this area of international basic and applied science well into the twenty-first century. TIGER will be linked to Hobart's Antarctic Adventure to provide 'real-time' radar pictures of the Aurora Australis as part of an exhibit to inform the public on the majestic lights that appear south of and at times above Hobart.

Anthony Breed & Ray Morris,
Atmospheric & Space Physics Program, AAD
Peter Dyson and John Devlin, La Trobe University

Davis LIDAR commences atmospheric observations



MARK TELL

A POWERFUL GREEN LASER BEAM IS NOW ROUTINELY probing the skies above Davis in the investigation of climate change at high altitudes. The laser light is being transmitted by a novel atmospheric Light Detection and Ranging (LIDAR) instrument developed by the AAD in collaboration with Adelaide University. During the 2000-01 summer, Atmospheric and Space Physics (ASP) Program and AAD trades personnel installed and commissioned the instrument at Davis, a culmination of five years of preparation by ASP, Science Technical Support and Engineering Branch staff.

The Davis LIDAR is a remote sensing instrument which profiles atmospheric density, temperature and wind velocity as a function of altitude. It operates in a manner akin to radar; pulses of laser light are transmitted into the sky, and the weak 'light echo' scattered back to the instrument from atmospheric gases and aerosols is collected and analysed.

The LIDAR is housed in a modular 'observatory' which consists of a temperature-controlled laboratory, an ambient-temperature enclosure with a retracting roof, and a general-purpose operations room. The observatory was progressively fitted out and tested at Kingston between early 1997 and mid-2000, and was shipped to Davis by RSV *Aurora Australis* on voyage one. Only three weeks were required to reassemble and commission the building.

The first LIDAR observations from Davis were undertaken in early February 2001. Initially, the instrument was operated in a 'biaxial' configuration, with the laser beam being transmitted independently of the receiving system. An advantage of the biaxial configuration is that it allows backscatter to be received from altitudes up to the mesopause (around 90 km) which is currently an area of intense interest in the atmospheric sciences community. There is evidence to suggest that the mesopause region may be cooling as a result of the current warming trend near the Earth's surface. Tenuous clouds of ice particles form near the mesopause in the summer at high latitudes. The visual manifestations of this phenomenon are called 'noctilucent clouds', and these have been observed by expeditioners at Davis, albeit rarely. One of the first tasks of the LIDAR is to examine the frequency of occurrence and structure of these clouds.

The Davis LIDAR is currently one of only three such instruments capable of retrieving temperatures in the mesosphere (the region between 50 km and about 95 km) from the southern hemisphere. Northern hemisphere measurements have suggested that a general cooling is taking place in the mesosphere and stratosphere (15 km to 50 km altitude), but little published data currently exists regarding trends at southern latitudes.

Biaxial operation will also allow further testing and refinement of the mechanical and optical system as the low temperatures of winter set in. Currently, a program of temperature comparisons between the LIDAR and Bureau of Meteorology balloon-borne radio-sondes is being undertaken up to altitudes of 40 km in order to test the LIDAR temperature retrieval techniques. It is hoped that the 'coaxial' operating mode of the instrument, in which the laser can be steered around the sky for horizontal wind measurements, will be tested before spring.

Andrew Klekociuk,
Atmospheric and Space Physics Program, AAD

Antarctica Online

Specific information on the instrument and its scientific program are outlined on the LIDAR web page at http://www.aad.gov.au/science/AntarcticResearch/AtmosphericSciences/lidar.asp.

Recent advances in medical research

Testing expeditioners in the cold room at the AAD's Kingston headquarters before they head south. Glenn Jacobson

Thirty years ago Australian Antarctic Division (AAD) medical practitioners commenced the first immunological studies on the Australian National Antarctic Research Expeditions (ANARE). In the intervening years many research projects have been performed[1,2,3] in collaborative studies between AAD and international and national universities and agencies.

One such recent collaboration, under the leadership of Professor William Shearer of Baylor College of Medicine, Houston, Texas, USA, saw doctors from AAD collect thousands of specimens of blood, cells, urine, and saliva from volunteers at all ANARE stations during winter 1999 for later processing at that institute, the University of Texas MD Anderson Cancer Center, Houston and the University of Washington, Seattle. Support for the study came from AAD and NASA through the National Space Biomedical Research Institute (NSBRI).

The eight-month total physical isolation at Casey was employed as an analogue for longer duration space flight and the T cell-dependent neo-antigen ϕ X 174 bacteriophage was used to determine if this isolation would alter human antibody responses. Macquarie Island subjects were used as a control group.

Bacteriophage ϕ X 174 is a virus which infects bacteria but which does not replicate or cause illness in humans. It can induce antibody responses in humans and over the past 30 years has been used to identify abnormalities in the primary (IgM) and secondary (IgG) antibody responses in immunodeficient and immunosuppressed patients.

All the subjects at Casey cleared the bacteriophage normally by one week after primary immunization and all had normal primary and secondary antibody responses, including immunologic memory amplification and a switch from IgM to IgG antibody production. The data did not support the hypothesis that *de novo* antibody responses of subjects become defective during conditions of winter in Antarctica[4]. This is an important finding for Antarctic expeditions as, although no disease could be associated with altered immune changes in ANARE groups in the past,[5,6] such immune changes may have important long-term health implications.

Mucosal immunity studies were conducted at all ANARE continental stations in 1992 to address the concern that immuno-suppression may occur in expedition staff and be associated with the anecdotal observation of an increased incidence of infections in staff when winter isolation is broken. The study just published[7] revealed significant changes in salivary immunoglobulin values over the period in Antarctica, with similar patterns at all three Australian stations. Immunoglobulin levels (IgA and IgM) were lower in the first four months in Antarctica, with increases to maximum values after midwinter, before returning to mean levels when isolation was broken and new expeditioners arrived. The pattern suggests that stressors due to isolation may play a role in alterations of mucosal immunity.

Further work is proceeding at all stations in 2001 on the role of environmental stressors (cold) in altered immune responses as well as into cold adaptation. This was made possible by the signing of a Cooperative Research and Development Agreement in April 2000 between the AAD and the United States Army Research Institute of Environmental Medicine (USARIEM) for long-term collaborative research into areas such as thermal physiology, cold climate clothing, stress and adaptation, predictive modelling, and the role of environmental stressors in altered immune responses.

The first studies under this new Agreement were performed in September/October 2000 in Hobart, when shortly before sailing south, 35 volunteers from the 2001 ANARE were exposed in a cold room at 5°C for 120 minutes while dressed only in underwear and a light paper smock (see photograph above). Deep core temperature of each was collected via a radio temperature pill and stored in a small data logger. Skin temperatures were measured with thermistors attached to the chest, arms, and thighs and connected to an continuous monitoring system. Rate of oxygen uptake was determined every 20 minutes during the 120 minutes cold stress test and samples of blood were taken for assay of factors such as catecholamines, vasopressin, anti-diuretic hormone, immunoglobulins, neuropeptides and melatonin.

The purposes of this protocol are:

1) to quantify shivering thermogenesis associated with deep core temperature and specific skin temperatures during a standardised cold stress test, prior to and following an Antarctic expedition;

2) to confirm if there is a reduction in specific cytokines during prolonged Antarctic exposure. A major goal is to document whether such changes have a direct association with depressed thermoregulatory responses following prolonged Antarctic exposure;

3) to develop specific algorithms applicable for the cold acclimatised state that can be used to validate cold stress prediction models.

The results of the pre-departure phase of this study have already been accepted for presentation at the International Thermal Physiology Symposium in Wollongong in September 2001.

Monthly blood collections are currently in progress at all four stations, and a repeat of the cold room stress test will be conducted on the volunteers when they return to Australia in early 2002.

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1. Lugg DJ. ANARE Medical Research: what did happen to all those specimens, Doc? In: Proceedings of the ANARE Jubilee Science Symposium, Hobart, July 1997. In Press.
2. Lugg DJ, Shepanek M. Space analogue studies in Antarctica. *Acta Astronautica* 1999; 44: 693-699.
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5. Tingate TR, Lugg DJ, Muller HK, Stowe RT, Pierson DL. Antarctic isolation: immune and viral studies. *Immunol Cell Biol* 1997; 75: 275-283.
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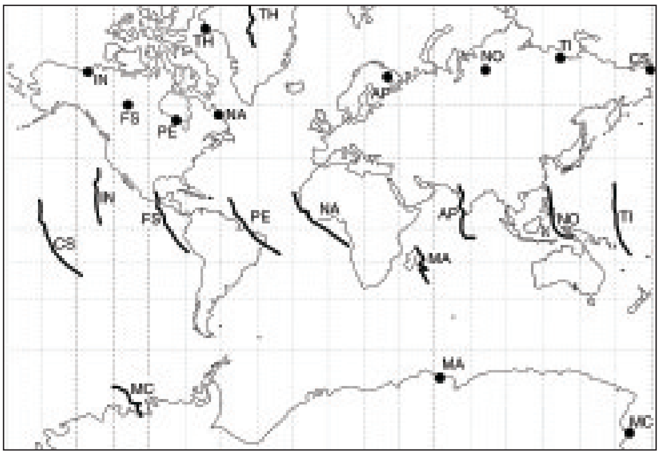
D. J. Lugg and P. Sullivan,
Polar Medicine, AAD

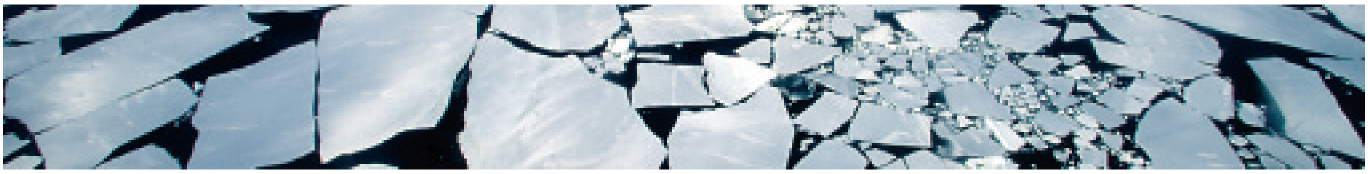
Space Ship Earth: monitoring space weather



The location (filled circles) and viewing directions (heavy lines) of the Space Ship Earth network of neutron monitors.
The stations are: Apatity (AP), Cape Schmidt (CS), Fort Smith (FS), Inuvik (IN), Mawson (MA), McMurdo (MC), Nain (NA), Norilsk (NO), Peawanuck (PE), Thule (TH) and Tixie Bay (TI).

Space Ship Earth is the brainchild of Prof John Bieber of the Bartol Research Institute, University of Delaware. The Earth is travelling through space in the inner part of the solar system and is the perfect platform for making measurements of the high-energy radiation environment of the region. Thus the name of the collaborative program. The consortium comprises Prof John Bieber and Prof Paul Evenson from Bartol, Dr Evgenia Eroshenko and Dr Anatoly Belov from IZMIRAN (Institute of Terrestrial Magnetism, Ionosphere and Radiowave Propagation) in Russia and Dr Marc Duldig from the Australian Antarctic Division. A network of polar neutron monitors will give real or near-real time measurements of the high-energy radiation environment surrounding the Earth. The polar monitors have been carefully selected to give narrow longitudinal bands of view at equatorial latitudes with a further two monitors viewing in polar directions (see figure). The Mawson and Inuvik monitors are crucial elements of the system because they have the narrowest longitude spread. They will characterise event arrivals more tightly than the rest of the network. Data will feed directly to Bartol for analysis and forwarding to industry and governments. The near-real time 3-D monitoring of the radiation will greatly benefit spacecraft operators and will be one input to now-casting of space weather. It is hoped that studies with this unique linked system will lead to improved prediction of space weather and the space radiation environment. Of particular interest will be the rare 'Ground Level Enhancement', blasts of particle radiation arriving from the Sun. These can produce increases of several hundred percent at ground level but are much larger above the protective layers of the atmosphere. The higher dose but lower energy radiation arrives some 20 minutes or so later allowing predictions to be provided to relevant space authorities. Also of interest will be Forbush decreases that occur with geomagnetic storms. These decreases show evidence of precursors a day or more in advance and may be of value in space weather prediction. The Mawson cosmic ray observatory will be enlarged over the 2001–02 season and additional detectors installed the following summer in readiness for this exciting new program.

Marc Duldig, Cosmic Ray Physics Program Leader, AAD



Australian Antarctic Science Grants for 2001-2002

Senator the Hon. Robert Hill has approved the following Australian Antarctic Science Grants for 2001-2002. Funds totalling $653, 159 (GST inclusive) were allocated among 49 projects from researchers based at 18 institutions.

Institution	Chief Investigator	Project Title	Amount of Grant
Australian National University [ACT]	Skotnicki, Dr Mary	Conservation of plant biodiversity in Antarctica - a genetic approach	$18,810
	Skotnicki, Dr Mary	Investigation of virus biodiversity in Antarctic terrestrial plants	$7,700
	Tregoning, Dr Paul	Crustal rebound in the Lambert Glacier area	$15,400
			[$41,910]
James Cook University [QLD]	Jones, Dr Graham	Factors affecting DMS in the seasonal ice zone	$22,000
			[$22,000]
La Trobe University [VIC]	Essex, Dr Elizabeth	Mapping the GPS total electron content and scintillation activity at southern higher latitudes during high sunspot numbers	$18,150
	Dyson, Professor Peter	Upper atmosphere dynamics and thermodynamics	$11,000
	Dyson, Professor Peter	Investigations of Space Weather and the Mesosphere using the TIGER Radar	$22,000
	Goldsworthy, Dr Simon	The conservation of fur seals in the antarctic marine ecosystem	$27,423
			[$78,573]
Macquarie University [NSW]	Gore, Dr Damian	Palaeoenvironments of the Antarctic coast, from 50E to 120E	$11,000
	Gore, Dr Damian	Glacial history of the Framnes Mountains, East Antarctica	$17,215
			[$28,215]
Southern Cross University [NSW]	Slade, Dr Rob	Isolation and characterisation of arboviruses in seals and birds	$10,670
			[$10,670]
Tasmanian Parks & Wildlife Service [TAS]	Gales, Dr Rosemary	Status and conservation of albatrosses on Macquarie Island	$22,000
			[$22,000]
University of Adelaide [SA]	Vincent, Dr Bob	Dynamical coupling in the Antarctic middle atmosphere	$17,050
			[$17,050]
University of Canberra [ACT]	Pearson, Professor Colin	Deterioration studies, archaeological investigations and structural assessments of Mawson's Huts (Cape Denison)	$2,200
			[$2,200]
University of Melbourne [VIC]	Bye, Dr John	Modelling the formation and subduction of subantarctic mode water in the South Australian Basin	$16,500
	Simmonds, Assoc Prof Ian	Recent changes in the semiannual oscillation in the sub-Antarctic and their connections with cyclone variability	$18,700

	Simmonds, Assoc Prof Ian	The nature of the Antarctic Circumpolar Wave and its connections with Australian rainfall variability	$22,000
	Stevens, Professor Geoff	Development and application of particle separator technology for the removal of contaminated particulates from water in Antarctica	$7,700
	Ward, Dr Simon	The distribution and abundance of nesting sites of flying seabirds in eastern Prydz Bay	$9,900
	Wilson, Assoc Prof Chris	Proterozoic and Palaeozoic evolution of the Rauer Group	$3,575
	Wilson, Assoc Prof Chris	Structure and dynamics of the Sorsdal Glacier	$16,500
			[94,875]
University of Newcastle [NSW]	Fraser, Professor Brian	Observations of ULF space plasma waves in Antarctica	$22,000
	Fraser, Professor Brian	A Southern Hemisphere imaging riometer experiment (SHIRE)	$19,848
			[$41,848.40]
University of New England [NSW]	Smith, Dr Steve	Spatial and temporal variation in the recruitment of benthic macroinvertebrates to artificial substrata	$5,423
			[$5,423]
University of New South Wales [NSW]	Burton, Dr Michael	The automated astrophysical site testing observatory	$10,890
			[$10,890]
University of Queensland [QLD]	Bergstrom, Dr Dana	Regional Sensitivity to Climate Change in Antarctic Terrestrial Ecosystems [RiSCC]: the periantarctic region	$18,167
			[$18,166.50]
University of Sydney [NSW]	Clarke, Dr Geoff	The strength of the lower continental crust; evidence from Stillwell Hills-Oygarden Group coastline	$9,350
	Deen, Ms Tara	Tomographic inversion of seismic data over holocene drift deposits from the George V Continental shelf, East Antarctica	$3,300
AMMRC	Rogers, Dr Tracey	Leopard Seal Program	$15,400
			[$28,050]
University of Tasmania [TAS]	Bowman, Dr John	Bacterial hydrocarbon degradation and impacts of hydrocarbon pollutants on microbial communities within Antarctic coastal sediments	$7,480
	Coleman, Professor Richard	Amery Ice Shelf Dynamics from GPS	$20,900
	Coleman, Professor Richard	GLAS Validation on the Amery Ice Shelf	$11,752
	Davidson, Dr Garry	Tectonic, magmatic and hydrothermal evolution of ocean floor spreading at Macquarie Island	$8,580
	Jackson, Dr George	Squid in the antarctic and subantarctic, their biology and ecology	$4,180
	Kamenetsky, Dr Dima	The distribution of volatile and metallic elements in the Macquarie Island glasses and melt inclusions: Implications for fractional crystallisation and degassing during seafloor basaltic magmatism	$8,800
	Kiernan, Dr Kevin	Geomorphological evolution of Heard Island	$7,150
	McMinn, Assoc Prof Andrew	Ecology and local impacts on near shore marine benthic algal mats	$18,322
	McMinn, Assoc Prof Andrew	Sea ice primary production off eastern Antarctica	$22,000
	Nunez, Dr Manuel	UV climate over the Southern Ocean south of Australia, and its biological impact	$9,900
	Quilty, Professor Pat	Evolution of East Antarctic marine environment during the Neogene	$4,268
	Reid, Dr James	A comparison of sea-ice thickness measurements made using ship-mounted and airborne electromagnetic induction devices	$6,380
	Roberts, Dr Donna	High Resolution palaeoclimate analysis of the Windmill Islands: the last 200 years	$1,320
	Williams, Dr Ray	Near-coastal distributions of icebergs, derived from SAR and Landsat MSS data using semi-automated image analysis techniques	$9,900
			[$140,932]
University of Western Australia [WA]	Kennedy, Dr Andrew	Impact of global environmental change on the terrestrial biogeography of Antarctica	$20,891
	Shellam, Professor Geoff	Investigations of bacterial, viral and parasitic infections in Antarctic and the development of a standardised monitoring scheme	$16,995
	Shellam, Professor Geoff	South polar skuas as vectors of disease	$8,800
			[$46,686.20]
University of Wollongong [NSW]	Davis, Dr Andy	Effects of UV radiation on community establishment: a global perspective	$14,586
	Robinson, Dr Sharon	Assessing UV-B induced DNA damage in Antarctic plants: is desiccation a compounding factor?	$21,934
			[$36,520]
Western Australian Museum [WA]	Godfrey, Dr Ian	Research in natural freeze-drying technology for the preservation of historic Antarctic buildings	$7,150
			[$7,150]
Total			**$653,159**

Making things happen: supporting our Antarctic program

Top: Inflatable rubber boat conveys equipment from Casey to scientists at their remote field camp on Browning Peninsula. Left: Scientists and field training officer discuss deployment of personnel and equipment with the helicopter pilot. WAYNE PAPPS, ROB EASTHER

ON MOST OF THE POSTERS PRODUCED BY MEMBERS OF THE Operations Branch of the Australian Antarctic Division over the past year, somewhere the words 'WE MAKE IT HAPPEN!' would have been displayed.

It has not been unusual to hear comments such as, 'and so do lots of other people!' in retort. Of course the 'retorters' are right, but that does not take away from the fact that, for those of us who work in the Operations Branch, this phrase reflects what we believe we are all about—our single purpose in life if you like—to make the things that are important to ANARE happen!

I boast unashamedly that what we Australians do in our operational and logistic work is best practice in Antarctic terms; even so, it is readily apparent that on occasions some of the things we have made happen in the past were not entirely to the total satisfaction of all of our customers. As a result, over the past six months and with generous assistance from many people across the whole of the program, we have started to learn a great deal more about what would improve the activities we are responsible for; in the process we have been presented with an opportunity to demonstrate our willingness and readiness to shape the future of ANARE operational and logistic support arrangements.

Let me say that the challenge of meeting the diverse range of expectations of the community we serve should not be underestimated. It is not just the variety of tasks, their complexity or the technical variation that make the work of the branch interesting; but, as is proper, the level of support required can vary markedly between projects. It is entirely reasonable to have a rudimentary level of service delivery for one type of project/program, meaning no cooks and bottle washers, AANBUS panels or spa baths if that is what the program dictates. However, for others where there is a need for our customers to undertake important data collection and analysis that

Aircraft operations infrastructure and Basler DC3 at Blue 1 airfield were inspected by senior AAD operatitonal staff this summer.
Kim Pitt

may be time dependent, physically demanding or time consuming, it can be quite different. On these occasions it is definitely more appropriate to provide additional support staff to set up and run camps, prepare and maintain appropriate levels of infrastructure or to act as field assistants—and we must be ready to provide for each.

Along with this comes the requirement that we have the expertise, experience, commonsense and courage to advise people when it is not possible, practical, affordable, environmentally appropriate, safe or sensible to provide what they seek. Although 'the customer may *not* always be right' we will always explain why, where it is possible offer alternatives, and keenly seek advice from all quarters, so that the service provided is as close as possible to what was requested.

The successes of the past are many but there have been problems along the way. No matter how good the eventual outcome has been, we recognise that there is no reason for complacency; it is a fact that, despite the Herculean efforts of those involved, interactions between service providers and customers have not always achieved the desired end state. This is a key future objective of the Operations Branch. The absolute need for improved ways of working to understand the needs of customers and, in return, to give them a realistic understanding of the capabilities and limitations of the support available, is central to successfully 'making things happen'.

This is not the time nor the place to write about organisational change, but some of that is inevitable as we move forward. The objectives of the Branch in this regard are simply to work even better as a part of the bigger AAD team that makes ANARE happen, to be truly customer-oriented, to be better at managing and documenting what we do, and always to keep our eyes on the ANARE operational and logistics 'ball'.

In other terms, over the past year there has been a realisation that, like in commerce, focussing on the successes of the past while not reacting to the changing shape of the client's needs, could send the business under. For all of us it would be great to be recognised as the world-wide leaders in the conduct of safe, environmentally sensitive and cost effective programs in Antarctica—and at the same time to have everyone feeling fulfilled and happy with their lot. I really think that this is achievable and to be 'the best little operator in Antarctica' is not as far away as some might think; over the past year I have visited more than 12 different stations/major field camps operated by eight different nations, and each of these visits alerted me to ways that we could do better ourselves; however, at the same time it was exciting to realise that our processes and procedures are very good indeed and that with some focussed effort we could be the best of them all.

So this is where the Operations Branch is heading with its programs of the moment. In conceptual terms the branch is looking for more cost effective, safe and environmentally sensitive ways of providing support to ANARE. In practical terms we are embarking on some very interesting projects and activities, for example:

• The development of proposals for detailed practical solutions to meet the infrastructure and support requirements discussed in the ANARE Chief Scientist's report to the Management Planning and Action Group (MPAG) in December 2000.

• The interim ship charters and the present helicopter charter will serve us well for the next few years while the Air Transport Project team completes its work. In the meantime, starting shortly, work on requirements for new ships and helicopter charters will be progressed.

• Reduction of costs is a big issue and it is very pleasing that the long-running station energy conservation program has delivered such good results; more recently the ability to better manage the usage of energy using the BMCS has been truly exciting and the next step to save money includes the potential introduction of wind turbines able to provide a significant proportion of a station's power (with attendant savings in fuel costs and reduction in environmental risk).

• An alliance on waste management remediation of tip sites with the Human Impacts Research Program is proving very fruitful and a joint project to operationalise

From top: Aurora Australis, Polar Bird *and AS350B (Squirrel) helicopters, key elements in the logistic infrastucture of Australia's 2000-2001 Antarctic program.* At right: *Assistant Director for Operations Branch, Kim Pitt (on ladder), and Director Tony Press, board* Polar Bird *in the Derwent River to greet returning Antarctic expeditioners.* WAYNE PAPPS

their research is progressing.

• Improved oil spill protection measures are under development and the huge efforts of the Human Impacts Research Program are driving the Branch's efforts towards real best practise solutions.

• An in-house cultural change program has begun; polishing and cherishing the strengths of our ANARE traditions will be encouraged, as will the letting go of those that no longer help the Branch to 'Maintain Strategic Fit'.

• New approaches to Antarctic and subantarctic infrastructure design—looking for those that guarantee flexibility, economy and easy removal will be embodied in a project framework.

• Master plans for each of the research stations are almost complete and the procedures for managing those plans will bring structure to managing the station infrastructure.

• The limited use made of our research stations by wintering scientists, and the opportunities offered by different transport options, will result in a review of wintering processes—including engineering issues, population numbers and skill requirements.

• The training review of 2000 will be advanced to improve even more courses and strengthen the program for recognition of prior learning.

• With the introduction of more formal Risk Management Policies & Procedures across the whole of Government, comes reinforcement of the need for properly designed and tested contingency plans, the need for improved presentation and document control of the procedures used in times of crisis & emergency, and also for formal processes for following up on lessons learned.

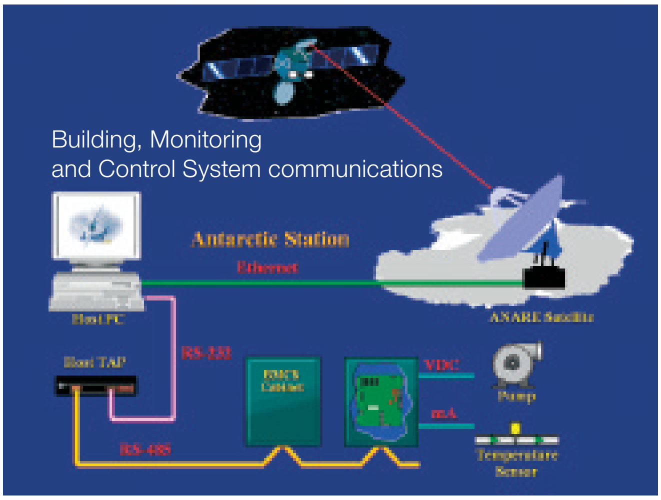
• The Branch has changed organisationally to include environmental responsibility as an equal partner with financial and safety responsibilities; next we will work closely with those embarking on the development of the new Environmental Management System (EMS) to ensure that our evolving organisational processes for the practical implementation and monitoring of environmental policies and for promoting the use of best practise procedures in all of the AAD's work in support of ANARE, are totally compliant with and integrated into the EMS.

But the long and the short of it all is that at the start of this millennium, the level of commitment from the Operations Branch team to delivering the very best outcome for ANARE is unequalled and with everyone else, we assert that we are on the right track for the future.

"We Make It Happen!"

K Pitt, Assistant Director, Operations Branch

Reducing energy use at Antarctic stations



Jeremy Bonice

Australia's four permanent stations—Casey, Davis, Mawson and Macquarie Island—have a primary role as a base for the support of science. In 1997, the Antarctic Science Advisory Committee (ASAC) questioned the ongoing need for four permanent stations and suggested that a more flexible approach to supporting science may be more appropriate. The option of closing or mothballing one or more stations was suggested as one means of funding this flexibility.

Unfortunately, the integrated nature of the stations, primarily due to the use of heating water as the main means of heating the station buildings, makes the concept of mothballing, even for a single winter, a difficult and costly exercise. As a result, opportunities to reduce the operating costs of the stations through efficiencies in their operation are actively being sought. The aim is to provide the required flexibility with stations that are available throughout the year, but that require minimal costs to operate during the times of reduced station population.

This article discusses the use of a Building Monitoring and Control System (BMCS) as a tool to better understand the various engineering systems in place at Australia's continental stations so that their operation may be monitored and optimised.

Station Description

In the early 1980s Australia commenced a program of replacing the old timber station buildings with modern, steel-framed, energy-efficient buildings. This rebuilding program was completed in the mid-1990s, leaving Australia with large, modern and comfortable stations.

The stations consist of a number of discrete buildings to reduce the impact of any fire. The buildings are thermally efficient and have sophisticated heating and ventilation systems.

Power at the stations is produced using diesel generator sets. Each station has two powerhouses and the main powerhouse at each is fitted with four generator sets of 110 kW rated capacity. As station electrical load varies, either two or three of these engines is required to meet the electrical needs of the station.

Maximum use is made of the waste heat that is generated in the powerhouses by using it to heat water. This hot water is pumped around the stations and provides the primary means of heating the buildings. Fuel-fired boilers supplement this system when required. As a result of the integrated nature of the engineering systems on the stations, the systems need to be managed as a whole to allow the station energy usage, and hence operating costs, to be minimised.

The first step in managing any system is to understand it. A BMCS has been installed at Casey, Davis and Mawson stations, initially to monitor systems and provide data, and then to allow systems to be centrally controlled to optimise their use.

The Building Monitoring and Control System Basics

A control system is not unlike a standard computer system in that it consists of inputs, outputs, hardware and software:

- The inputs to a control system are in the form of sensors and switches such as temperature sensors or push button switches.
- The hardware in the Australian Antarctic Division's case is a Single Board Computer (SBC). Other sorts of control system hardware include Distribution Control Systems (DCS), Programable Logic Controllers (PLC) or Micro Controllers.
- The outputs for a control system can be either hardware-based such as starting a pump, opening a valve or turning on a light, or software-based such as raising an alarm, collecting field data or undertaking calculations.
- Software in a control system is usually programable by the end user. Its main purpose is to let the hardware know how to monitor the inputs and control the outputs. Our system software is 'inet 2000'.

The BMCS Project

The BMCS project commenced in late 1997. The initial step was to commission an audit of the existing local monitoring and control system (LMCS) and of the engineering systems at the stations in an attempt to quantify the value of any savings that may result from an upgrade to the LMCS. However, the impetus for the project came when the audit revealed that the existing data loggers used by the LMCS were not Y2K compliant. Additional funding became available in mid-1998. A specification was developed and tenders called in late

1998. A preferred tenderer was selected, and work commenced with a view to delivering equipment to the stations on the last voyage of the 1998–99 season.

This deadline was met, and in February 1999 the system was despatched with recently recruited and trained electricians to Mawson, Davis and Casey.

Across the three stations a total of 63 cabinets containing 115 Process Control Units were installed. Over the next five months, the Project Electricians between them connected up approximately 2,800 of the existing sensors and switches. Programing was carried out concurrently with the installation of the sensors and switches and was completed in October 1999. Thus, the initial system was up and running within eight months of the arrival of the equipment.

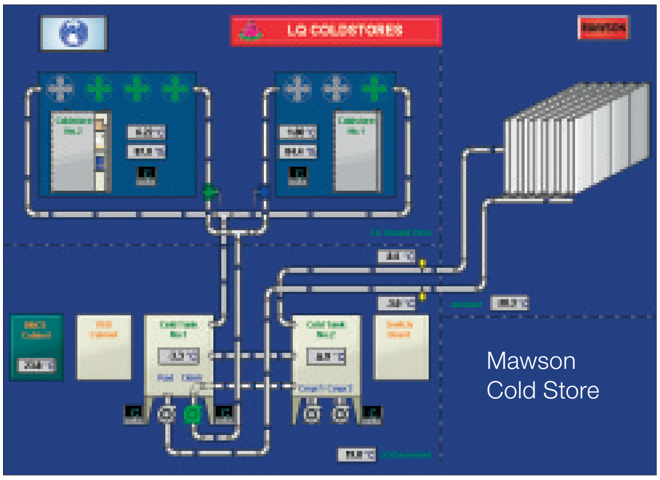
The present system can be monitored, programed and configured from the AAD's head office at Kingston. This is achieved through the AAD's satellite-based Wide Area Network. This is particularly useful feature of the system in that it provides a way in which Head Office engineers can assist the on-site trades people in the maintenance and operation of the stations.

Monitoring to Date

It was mentioned earlier that hot water is pumped around the stations and provides the primary means of heating the buildings. The system of pipes, locally referred to as 'Site Services', that carry the heating hot water also carry potable and fire sprinkler water as well as the sewage (though not all in the same pipe!). These pipes are heat traced, which is perhaps best described as 'electric blankets' on the pipes. Designed to turn on when the pipe gets too cold, they prevent the pipe from freezing. The BMCS monitors the temperatures within these pipes and the status of the heat trace, and has been used to safely reduce the time that the heat trace is on, thus reducing the energy used by the system.

Water production at Mawson and Casey consists of a melt bell that utilises heat from the site services, supplemented by a diesel-fired boiler, to melt fresh water in melt lakes adjacent to the stations. At Davis, a reverse osmosis plant produces water over the summer months from a saline tarn. This water is stored in two 600 kl tanks for use over winter. The BMCS monitors the flow and pressure of the potable water system, and has been connected to storage tanks to give an indication of water levels and water production rates.

Within the main buildings, the BMCS is monitoring the temperature in a range of building spaces and controlling primary and zone specific air heating coils. More recent modifications have allowed the BMCS to control the whole heating, ventilation and air handling systems of some buildings to reduce the energy consumed while maintaining the building amenity. The system also monitors the status of electrical switchboards, fire panels and powerhouse engines.



JEREMY BONICE

Other uses to date include using the BMCS to monitor air quality (CO_2, CO, Methane and Hydrogen Sulphide), and to monitor wind speed, wind direction and relative humidity through an interface with the meteorological automatic weather stations. A recent innovation uses the text alarms generated by the system to send alarms to pagers that are capable of receiving text messages. This system allows a duty trades person to be in 24-hour contact with the equipment for which they are responsible. Some quantified case studies are provided to illustrate the typical savings and efficiencies that have been achieved to date.

Mawson Cold Store Project Case Study

At Mawson station, a new cold store was constructed over the winter of 1999. The cold store uses outside radiators as heat rejection units and has conventional refrigeration compressors as a backup. The final result is two energy-efficient cold stores used for the long-term storage of fresh food, one at 6°C and one at 2°C.

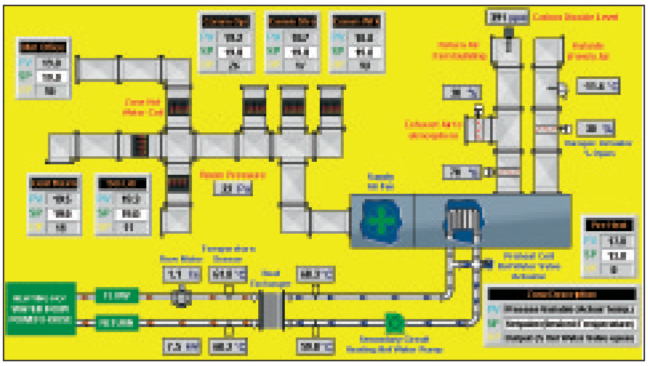
When completed, the cold stores used on average 20 kWh per day compared to the original refrigerated containers that had an estimated usage of over 100 kW per day. The BMCS was connected to the system over the 1999-2000 summer to control the number of fans and pumps in use, and the total energy usage of the cold stores dropped to 16 kW—a saving over the 'uncontrolled' system of 20%. Over the 2000 winter, the colder outside temperatures allowed usage to drop to approximately 7 kW per day.

Davis Workshop Lighting Project Case Study

An energy audit was undertaken at Davis Station in 1998. An analysis of the results revealed that the Davis workshop seemed to have an inexplicably high energy usage, especially when compared to other similar sized buildings. Investigations revealed that the lighting was a major consumer of electrical power. The latest lighting systems were researched and it was decided to replace the existing system.

A total of 327 old fluorescent tubes were replaced with 172 triphosphur tubes mounted in new mirror-like reflectors. The new lights were rotated to maximise use of reflection from walls, and lowered. They were also powered through a proprietary 'Eco-Box' light voltage control system. The light switching system was also replaced using Clipsal's C-BUS technology. This allowed the automatic switching on of lights to provide a pathway, it allowed people to choose the amount of light they required, and it provided a means for people to switch off all the lights in the workshop with a single switch located at each exit. The C-BUS system included 15 PIRs, a total of 50 new switches, and the grouping of lights into 44 groups. The whole building was then connected to the BMCS for duplicate control. The end result was a 40% increase in the light levels available.

Other changes in the building included BMCS control of the air handling system, the workshop air compressor, and the floor heating coils. The total reduction in energy usage as a result has been estimated to be 56%. Based on the then pump price for diesel, this represents a pay-back of less than two years.



Jeremy Bonice

Mawson Heating Hot Water Pump Project Case Study

The design of the heating hot water pipe network includes a 'primary circuit' which travels around the station through each of the buildings. A 'secondary circuit' within each building uses a heat exchanger to remove the amount of heat required for the building from this primary circuit. The original design of the system has the main circulating pump running at constant speed.

A Variable Speed Drive (VSD) controlled by the BMCS has been installed on the main site services heating hot water circulating pump over the 2000-01 summer. Initial results indicate that this may be our best ever return on investment! The variable speed drive slows down the rate at which the heating hot water is pumped around the station thus saving energy. It has no effect on the heating of the buildings as, during summer, they require very little heating.

When the pump operates in its normal mode, it consumes around 22 kW of power and pumps water around the station at a rate of 17 litres/second. Slowing the pump down to 70% (to 12 litres/second) the pump consumes 9 kW of power. Therefore, a 30% reduction in speed results in a 60% reduction in energy consumption. The VSD was initially run for almost three weeks from late December to mid-January and consumed 6.4 MWh of energy, compared with just over 10 MWh if the pump had run normally. Results such as these mean that the pay-back period, for all the materials and labour, is around 42 days. It is envisaged that savings can continue to be achieved up until the end of March and after that time, there will probably be no benefit as the pump will have to run at 100% of the time in order to keep up with the station heating load.

Conclusions

The BMCS project has allowed the Australian Antarctic Division to gain a better understanding of energy usage at the three Antarctic Stations of Davis, Casey and Mawson. It has also allowed the automation of some of the station engineering systems, which have allowed them to be optimised resulting in a reduction in operating costs of the stations. It is expected that a number of other projects will be able to be completed over the coming years that will allow the operating costs to be reduced even further.

Chris Paterson, Chief Engineer, AAD, & Jeremy Bonnice, Instrument and Control Engineer, AAD

Antarctic air transport link investigated

Over the past two years, the AAD has been investigating the possibility of implementing an air transport system. An air transport system would transfer expeditioners to and from Antarctica with the aim of providing access to the ice more rapidly and more often. Investigations commenced with the research of and writing of a 'Scoping Study' which examined all the different aircraft, airfield and routing options. Later, after field studies during the 1999-2000 summer season, a report entitled *1999-2000 Investigations* was released. This report recommends that an inter-continental air transport link be developed between Hobart and a compressed snow runway in the Casey area. It also recommends that an airfield at Bunger Hills be used as an 'alternate' and that further monitoring be carried out of snow and ice conditions in the Davis area. The report recommends that smaller aircraft be used to transfer expeditioners from Casey to Davis, Mawson and remote field locations.

The next stage of the air transport investigation is to identify a provider or providers who could carry out the various tasks associated with the system. These tasks

In whiteout conditions, company representatives inspect automatic weather station close to the proposed airfield site. One of the main concerns of air transport personnel is good meteorological data and forecasts for flights. Automatic weather stations are required at several locations to provide the necessary information. PHIL TRACEY

include construction of the airfield itself, provision of all the facilities that would be required (for example, accommodation at the airfields, fire fighting equipment, navigation equipment and airfield marking) and of course, provision of the aircraft themselves. The tendering process for the facilities has commenced. It is a two-stage process, consisting of an 'expression of interest' stage and a final tender stage. Six companies that are tendering to provide the aircraft have been selected from the 'expression of interest' stage. These companies were invited to send representatives to visit Casey on Voyage 5 during the 2000–01 season, and three of the companies were able to take up this opportunity. They were shown the station, including an examination of the infrastructure available, and they visited two proposed sites for the compressed snow runway inland of Casey.

The second 'tender' stage will be carried out during 2001. Also during 2001 risk and cost benefit analyses, including environmental impact assessments, will be carried out, so that by the end of the year a final decision on the implementation of the system can be made. If the decision is to proceed, construction of the runway in the Casey area could commence next summer season.

Jo Jacka, Air Transport Study Project Manager, AAD

Harnessing the power of the windiest continent

Test wind turbine at Casey Station collecting operational and engineering data while producing power for the Casey grid. AAD PHOTO

STUDIES INTO THE POTENTIAL OF ALTERNATIVE ENERGY systems such as wind and solar energy have been undertaken at the Australian Antarctic Division since 1992. These studies have shown that the use of wind power at Mawson and Macquarie Island may be economically viable if engineering and logistical hurdles can be overcome.

At present, a total of approximately 2.1 million litres of diesel fuel is used annually to provide power and heating at Australia's three Antarctic stations and subantarctic Macquarie Island.

In addition to the financial benefits of alternative enrgy systems, a substantial reduction in the use of fossil fuels at the stations will result in a reduction in the emission of greenhouse gases, and a reduced risk of fuel spills and damage to the environment.

The present focus of the Alternative Energy Program is Mawson station. An analysis of the electrical and thermal loads of the station, combined with a minimum number of suitable sites for a wind turbine, have resulted in a preferred solution of three to four turbines in the size range of 230 to 280 kW .

Work is presently underway at Mawson to reduce the station load. This will not only have immediate impacts on the quantity of fuel used, (and hence on the costs of refuelling the station), but may also reduce the requirement for the fourth, and possibly the third turbine.

An analysis of the world market of suitably sized turbines indicated that there are a number of

Safe and waterproof on Heard Island

When plans for a field season for scientists on Heard Island were declared, the hunt was on for a sturdy hut that was waterproof, portable, cheap to produce and able to be transported by a variety of means.

Experience has shown that reliance on tents to accommodate field workers in the extreme weather conditions on Heard Island is a fraught business. It is guaranteed to involve frequent re-pitching, chasing of gear and constant attempts to dry clothing and sleeping bags in conditions that will try the most experienced expeditioner. To make the best of the time on the island, it was essential to ensure a better standard of accommodation and workspace for members of the 2000–01 Heard Island ANARE.

And so was born the water tank hut—brainchild of AAD Field Equipment and Training Officer, Rod Ledingham. After all, what better for a rainy climate than a watertight container adapted as a hut, and what could be more watertight than a rainwater tank?

The concept was trialled a number of years ago on Macquarie Island when a 2.7metre diameter high-density polyethylene water tank was converted into a small hut for Davis Point as a refuge for a marine debris collection program. The hut was positioned by helicopter and has proven to be most effective.

The main problem with the early tank model was the great deal of condensation on the interior walls, which soaked bedding and fittings. This was partially solved by retrofitting closed cell foam matting on the walls. On investigating the possibilities of insulating, it was discovered there was a system whereby a secondary insulating layer could be cast on the interior during the rotary moulding process

The trial tank came out like a melted gumboot, but on the second attempt a perfect specimen with approximately 12 mm of insulation was formed. This 3.4 metre prototype was fitted out and found able to hold 6 bunks which could be moved and used as shelves or workbenches. There was also enough room for a set of 60 cm wide shelves from floor to ceiling. Windows were doubleglazed with polycarbonate attached to the interior and exterior surfaces. A door was fitted about 40 cm up from the floor so that the base remained waterproof. Ventilators and roof hatches were fitted.

A tank hut is towed through the surf by rubber boat to Aurora Australis *after housing glaciologists on the Brown Glacier at Heard Island during the 2000-01 summer.* Doug Thost

The polytank is virtually indestructable and therefore ideal for deployment in places like Heard Island. It is also relatively cheap ($2,000 to $3,000 with insulation) compared with the now famous fibreglass 'Apple' huts which are constructed as a series of panels and bolted together.

Fifteen tank huts have been used on Heard Island this season, delivered to Atlas Cove, Brown Glacier and Spit Bay by helicopter. Several were towed in the water by inflatable rubber boats and lifted onto the re-supply vessel, their self righting capability proven in trials before going to Heard Island.

Early reports from expeditioners are positive but we'll have more news on life in a water tank in the next edition of *Australian Antarctic Magazine*.

Rod Ledingham, Field Equipment and Training Officer & Rob Easther, Field Operations Manager, AAD

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from page 40

manufacturers who have turbine designs which are of the correct output. However, the harsh environment and severe wind speeds at Mawson, along with some of the other design characteristics of the available turbines, meant that there was only one preferred turbine.

Coincidently, similar sized turbines from the same manufacturer have been supplied to the township of Denham in WA under a Greenhouse Office showcase grant. In that case, the design criteria included the requirement for the township to run on 100% wind power when the environmental conditions are right.

The AAD is now working with the manufacturer and their Australian agent to jointly develop the world's first cold region turbine and control system—a system that is capable of running Mawson station without diesel fuel when the conditions are suitable. Wind modelling indicates that this could be as much as 80% of the time over the full year, and 100% of the time over winter.

An environmental impact assessment at the Initial Environmental Evaluation level is currently out for comment. If the project proceeds smoothly, the first work will occur on site in the 2001–02 summer.

Chris Paterson, Chief Engineer, AAD

Australian Antarctic shipping program 2000-01

	Arrive	Depart	Activity
Voyage 1 — Aurora Australis			
Hobart	29 September 2000	01 October 2000	On hire, load
Marine science	02 October 2000	12 October 2000	
Davis ice edge	25 October 2000	29 October 2000	Over-ice resupply, deploy summer personnel
Mawson ice edge—fly off	04 November 2000	05 November 2000	Deploy summer personnel using S76A helicopters
Heard Island	09 November 2000	10 November 2000	Deploy and retrieve summer personnel
Fremantle	18 November 2000	20 November 2000	Discharge, load
Voyage 2 — Polar Bird			
Fremantle	05 October 2000	08 October 2000	On hire, load
Heard Island	19 October 2000	25 October 2000	Deploy summer personnel using AS30B helicopters
Hobart	05 November 2000	06 November 2000	Discharge, load
Voyage 3 — Polar Bird			
Hobart	05 November 2000	06 November 2000	Discharge, load
Macquarie Island	09 November 2000	14 November 2000	Winter personnel changeover, resupply using AS30B helicopters
Marine science	20 November 2000	25 November 2000	
Casey ice edge—fly off	26 November 2000	19 December 2000	Deploy summer personnel (delayed by heavy ice)
Hobart	26 December 2000	30 December 2000	Discharge, load
Voyage 4 — Aurora Australis			
Fremantle	18 November 2000	20 November 2000	Discharge, load
Heard Island	29 November 2000	30 November 2000	Deploy and retrieve summer personnel
Mawson	04 December 2000	7 December 2000	Winter personnel changeover
Davis	09 December 2000	11 December 2000	Winter personnel changeover
Sansom Island—fly off	11 December 2000	15 December 2000	Restock fuel depot, support Amery program
Davis	16 December 2000	16 December 2000	Complete winter personnel changeover
Hobart	27 December 2000	01 January 2001	Discharge, load
Voyage 5 — Polar Bird			
Hobart	26 December 2000	30 December 2000	Discharge, load
Casey	28 January 2001	01 February 2001	Resupply and winter personnel changeover (delayed by heavy ice)
Hobart	08 February 2001	11 February 2001	Discharge, load
Voyage 6 — Aurora Australis			
Hobart	27 December 2000	01 January 2001	Discharge, load
Marine science	12 January 2001	23 January 2001	
Mawson	24 January 2001	26 January 2001	Deploy winter personnel
Casey	01 February 2001	02 February 2001	Assist Polar Bird enroute Casey–Hobart
Marine science	03 February 2001	22 February 2001	
Davis	25 February 2001	26 February 2001	Retrieve summer personnel
Marine science	27 February 2001	01 March 2001	
Hobart	10 March 2001	12 March 2001	Discharge, load
Voyage 7 — Polar Bird			
Hobart	08 February 2001	11 February 2001	Discharge, load
Mawson	24 February 2001	03 March 2001	Resupply
Zhong Shan/Law Base—fly off	05 March 2001	06 March 2001	Deploy CHINARE personnel and equipment using AS30B helicopters
Davis	07 March 2001	08 March 2001	Retrieve summer personnel
Heard Island	14 March 2001	20 March 2001	Retrieve summer personnel and camp
Hobart	31 March 2001	01 April 2001	Discharge, off hire
Voyage 8 — Aurora Australis			
Hobart	10 March 2001	12 March 2001	Discharge, load
Casey ice edge—fly off	20 March 2001	22 March 2001	Retrieve summer personnel using S76 helicopters
Marine science	22 March 2001	22 March 2001	Deploy sea ice buoy
Macquarie Island	28 March 2001	31 March 2001	Supplementary resupply and retrieve summer personnel
Hobart	03 April 2001	04 April 2001	Discharge, off hire

Voyage 1: Leader: Suzanne Stallman; Deputy: Gordon Bain
Voyage 2: Leader: Rod Ledingham
Voyage 3: Leader: Ian Allison; Deputy: Michael Johnston
Voyage 4: Leader: John Brooks; Deputy: Jenny Whittaker
Voyage 5: Leader: Ross Jamieson; Deputy: Gerald Harwood
Voyage 6: Leader: Graham Hosie; Deputy: Andrew McEldowney
Voyage 7: Leader: Vince Restuccia; Deputy: David Moser
Voyage 8: Leader: Martin Betts; Deputy: Leanne Millhouse

Human impacts in Antarctica: what are we doing?

Wayne Papps

Antarctica is often thought of as a pristine land untouched by human disturbance. Unfortunately this is no longer the case. For little more than a hundred years people have been travelling to Antarctica and in that short time most parts have been visited and we have left more than just footprints. We have driven some Antarctic species to the verge of extinction for economic benefit, killed and disturbed other species, contaminated the soils, discharged sewage to the sea and left rubbish, cairns and tracks in even the most remote parts. More recently attitudes have changed as we begin to realise that there are few unvisited places left on earth and that they of enormous value to humanity. The clean air, water and ice of Antarctica are now of global importance to science for understanding how the Earth's environment is changing both naturally and as a result of human activity. Tourist operators are beginning to tap the huge demand to visit the last great wilderness on Earth. Paradoxically both science and tourism have the potential to damage the very qualities that draw them to Antarctica.

Scales of Environmental Impacts in Antarctica

Environmental impacts in Antarctica may occur at a range of spatial scales. At the largest scale are the effects in Antarctica of planet-wide impacts such as global warming, ozone depletion and global contamination caused by the application of technology elsewhere in the world. More localised, but still with the potential to cause region-wide effects, are the impacts of fishing and hunting. Mining has been prohibited under the Environmental Protocol to the Antarctic Treaty. More localised still are the impacts of visitors, such as scientists or tourists, to the region, .

Global Impacts

Antarctica is important for understanding the global impacts of the industrial world for a number of reasons. Global change may have deleterious effects that impact directly on the Antarctic environment and its fauna and flora. For example global warming may contribute to break-up of large areas of ice-shelf and cause loss of habitat for animals dependent on the ice-shelf; increasing UV radiation may cause changes to phytoplankton communities and could have effects up the food chain. Global change may also bring about changes in the Antarctic that could have serious environmental consequences elsewhere in the world, for example changes in the amount of water locked up in Antarctic ice may contribute to global sea level change.

Finally, the Antarctic region is a sensitive indicator of global change. The polar ice cap holds within it a record of past atmospheres that go back tens or even hundreds of thousands of years, allowing study of the earth's natural climate cycles against which the significance of recent changes can be judged.

Impacts of Hunting and Fishing

Hunting for whales and seals drew people to the Antarctic in the early years of the 19th century and within a very few years caused major crashes in wildlife populations. The Antarctic fur seal was at the verge of extinction at many locations by 1830 causing a decline in the sealing industry, although sealing continued at a smaller scale well into the last century. The Convention on the Conservation of Antarctic Seals (CCAS) was initiated in response to concerns that the sealing industry could be re-opened after some exploratory research to investigate the viability of sealing in the 1960s. Although commercial sealing did not recommence, the CCAS does establish a regime for sealing and provides for permissible catch limits for crabeater, leopard and Weddell seals, and a zoning system with closed seasons and total protection for Ross seals, southern elephant seals and certain species of fur seal. However, under Australian law Australians would not be granted a permit for commercial sealing in the Antarctic Treaty area. The seal populations of Macquarie Island have been protected by the island's status as a wildlife sanctuary since 1933. The seals of Australia's sub antarctic islands were further protected in 1997 when both Macquarie and Heard and McDonald Islands were added to the World Heritage list. The exploited seal populations of the Southern Ocean have in recent years recovered very substantially and are no longer endangered.

Whaling in the Southern Ocean began in earnest in the early 1900s and grew very quickly so that by 1910 it provided 50% of the world's catch. The history of whaling is a repeated sequence of targeting the most profitable species, depleting stocks and moving on to previously less favoured species. Declining catches motivated international attempts to regulate whaling and led to the establishment of the International Whaling Commission (IWC) which first met in 1949. For many years the IWC had little success as an organisation that was established to manage whales as a sustainable resource, however falls in profits did succeed in driving many companies out of the whaling business.

In the 1960s the IWC became more effective when blue and humpback whales were fully protected; protection was extended to fin and sei whales in the 1970s and in 1986 the IWC decided to suspend all commercial whaling. Since the moratorium was initiated, whaling has been limited to one or two countries that undertake 'scientific whaling' purportedly as the basis for research.

Fishing in the Southern Ocean can have impacts on the target species and on other parts of the ecosystem unless it is carefully managed. STEVE NICOL

There are some indications that whale populations are beginning to recover but such long-lived species with low reproductive rates are incapable of rebuilding their numbers in just a few years.

Fishing is the only large-scale commercial resource extraction currently undertaken in the Antarctic Treaty area now that sealing and whaling have effectively ceased. The major impacts of fisheries are:

- potential for over-fishing of target species;
- effects on those species dependant on the target species as a food source;
- mortality of non-target species caught by fishing equipment; and
- destruction of habitat.

Over-exploitation has been a characteristic of most major fisheries world-wide and unless the controls established for the Southern Ocean fisheries are enforced they will be no exception to this. CCAMLR and the Australian legislation that implements the convention are different from the other environmental instruments relevant to the Antarctic as their aim is regulation of sustainable exploitation rather than outright protection. CCAMLR was established in 1981 at a time when commercial interests in krill were growing rapidly; it began to be truly effective as a management regime in 1991 when the first catch limits were set. From the outset CCAMLR was based on the principle that management of fisheries should include not just the target species but also dependent and associated species and their ecological relationships. As a consequence, much research effort has been directed towards understanding the interactions between krill and their predators. After the convention was established the krill fishery did not continue to grow as it had previously, partly because of the withdrawal of the Soviet fleet after the breakdown of the Soviet Union, but also because the cost of fishing and the value of krill in the market place meant that it was economically marginal. This hesitation in the growth of the industry has allowed some breathing space for those managing the fishery, however the economics are changing and

there is now demand for krill as a food source for aquaculture and bait. As a consequence the 1999 catch of 100,000 tonnes is likely to be soon doubled.

The fish of the Southern Ocean have been the subject of exploratory fishing since the start of the century but large-scale fishing did not develop until the late 1960s when the Soviet Union targeted marbled notothenid and icefish around South Georgia. The fishery has not recovered from the early peak (400,000 tonnes in 1969-70) and the subsequent rapid decline. The Patagonian toothfish has recently been targeted at a number of locations in the Subantarctic. The fishery has attracted unauthorised operators from several countries that are working outside the regulatory framework. Illegal, unregulated or unreported fishing is of concern because it has the potential to undermine attempts to manage the stock as a sustainable resource. In 1999 CCAMLR adopted a catch documentation scheme which will help prevent illegally caught fish entering the markets of CCAMLR nations. Illegal fishing is also a concern because it may involve the use of techniques that can cause the death of non-target species as by-catch. In particular, albatross are taken inadvertently by long-line fishing. CCAMLR has introduced a Conservation Measure to reduce the incidence of seabird mortality during long-lining. The Australian Fisheries Management Authority limits the fishery around Heard and Macquarie Islands to trawling to minimise the impacts on seabirds. The

The Human Impacts Research Program undertakes research as a basis for guidelines that will ensure visitors do not disturb Antarctic wildlife. MARTIN BETTS

Australian Antarctic Division has recently established a new program, Antarctic Marine Living Resources, to provide the scientific basis for ecologically sustainable management of Southern Ocean fisheries.

Bio-prospecting, or the collection of animals, plants and microbiota to explore their potential as sources of new chemicals of commercial value (pharmaceuticals, pesticides or in food processing) has occurred on a small scale in Antarctica. Large-scale collections of wild populations are unlikely even if a useful chemical is discovered due to the economics of activities in Antarctica. The precedent set elsewhere in the world is that synthetic analogues of biologically active chemicals are used in preference to continued harvest of natural populations. Aquaculture and the techniques of tissue culture and genetic modification are also being explored as methods for satisfying the demand for useful natural products.

Impacts of Visitors

With the exception of those involved in fisheries, most visitors to the Antarctic go either as tourists or as part of national scientific programs. In many aspects the type of activities undertaken and the potential environmental impacts are common to all visitors. Irrespective of their reason for being in Antarctica, people will visit sites with spectacular scenery and in particular will visit wildlife colonies. However, there are some significant differences.

Although nearly three times as many people visited the Antarctic as tourists (14,000) as part of the national programs (4,000) in the 1999-2000 season, the number of person-days on the ground in Antarctica for national programs far exceeds the number for tourism. This is because to-date national programs have been characterised by the establishment of permanent or semi-permanent stations, mostly in the ice-free areas, staffed by long-term (wintering) and short-term (summer only) personnel. Most large-scale tourists operations are ship-based and landings are limited to a few hours at selected locations. There is a trend towards more independent, yacht-based visits and to adventure activities such as over-night camping, mountain climbing and scuba diving but this is unlikely to increase the number of person-days ashore to the point that tourism exceeds government activity in the foreseeable future.

WAYNE PAPPS

The abandoned Wilkes station is scenic from a distance...

The main concerns for environmental management are how to ameliorate past environmental impacts and how to reduce current and future impacts. Within the Australian Antarctic program we are developing procedures for the clean-up and remediation of abandoned work sites and disused tip sites. In the early days of Australia's Antarctic program waste management consisted of disposal to open tips and the practice of *sea-icing* which involved pushing waste onto the sea-ice. Sea-iced material would travel out with the ice as it broke up at the beginning of summer to be dispersed among the marine environment. Commitment to the Madrid Protocol confers the obligation to clean-up abandoned work sites and waste tips so long as the process of clean-up does not cause greater adverse impacts or cause the removal of historic sites or monuments. Research is currently underway to develop cleanup and remediation procedures that will not cause greater impacts. Methods for detecting and monitoring impacts, particularly in the adjacent marine environment are also being developed.

Environmental audit, environmental impact assessment, a permitting system and a system of protected areas are among the arsenal of management tools available for reducing current and future impacts of activities in Antarctica. Environmental audit is used to assess our activities. A system of environmental impact assessment is included in the Madrid Protocol (and Australian legislation). The system, adopted by all nations operating in Antarctica, involves a preliminary assessment to determine the scale of impact likely and whether more detailed assessment is necessary. A permit system has also been established to regulate and monitor certain activities such as entry to protected areas and the collection of samples. The Madrid Protocol established a system for area protection and management, which will be used to protect areas of outstanding environmental, scientific, historic, aesthetic or wilderness value. This system replaces the system of Specially Protected Areas and Sites of Special Scientific Interest previously designated by Antarctic Treaty Consultative Meetings.

Some environmental disturbance an inevitable consequence of activities in Antarctica. These include emissions to the atmosphere such as exhaust; disturbance to the physical environment such as tracks from walking and vehicles; and disturbance to wildlife by visitors and vehicles. Environmental research and environmental management tools are used to reduce this disturbance. For example, research is being directed towards the potential for alternative energy sources to replace traditional fuels, the protected area system is used to ensure that vehicles are not used in particularly vulnerable landscapes and information from animal behavioural research is used as the basis for new guidelines to ensure that helicopters do not cause harm to aggregations of wildlife by flying too close.

Other, potentially more serious impacts, are not inevitable and may never happen but our presence in Antarctica means that there is a finite possibility that they will occur. Of particular concern is the risk of introducing species, including disease-causing species. Introduced species have caused major environmental problems on every other continent of the world and have caused significant changes to the ecology of most subantarctic islands. Although we can not remove the risk entirely, procedures are being developed on the basis of research findings to reduce the chance of introductions. Australia recently hosted the first international meeting to consider disease in Antarctic wildlife and has been

Rob Easther

...however, close-up the environomental problems at Wilkes are obvious.

asked to convene a group to develop practical measures to diminish the risk of introduction and spread of diseases to Antarctic wildlife.

Australian Environmental Initiatives

Protection of the Antarctic environment is one of the Government's four goals for the Australian Antarctic program and the ethos of environmental protection suffuses all aspects of the program. The AAD, as lead agency for the Antarctic program, ensures that everyone involved in the program is aware of their personnel responsibility to care for the environment. At appointment, all expeditioners must agree to abide by the Code of Personal Behaviour, which includes a practical commitment to Australia's environmental management responsibilities. Induction and training of new employees includes an introduction to the AAD's approach to environmental matters. At the Antarctic stations, the station leader is responsible for environmental management and is assisted by the station environment committee, a station environmental officer and a station waste management officer.

At the headquarters of the AAD at Kingston, the Environmental Management and Audit Unit and the Operations Environment Officer are responsible for ensuring that all activities are planned carefully to avoid environmental harm and to develop policies that minimise detrimental effects on the natural environment.

The Human Impacts Research Program undertakes research to ensure that environmental management decisions are based on the best scientific information. The AAD's Environment and Audit Committee brings together expertise from all sections of the organization to provide senior management with support when making decisions that have implications to the environment. The Antarctic Marine Living Resources research program provides information that will be of use in managing the harvesting of species in the Southern Oceans.

Internationally, Australia has taken a leading role in promoting environmental protection within the Antarctic Treaty System since its inception. Australians were active in establishing the Agreed Measures in 1964 and the decision by Australia and France not to sign the Minerals Convention and to push for a protocol that accorded comprehensive protection of the Antarctic environment led to the negotiating and signing of the Madrid Protocol. Australia is continuing its efforts within the Antarctic Treaty System to secure protection of the environment through contributions to the new Committee for Environmental Protection, which was established to provide environmental advice to the Treaty Consultative meetings. Scientists and policy advisors from the Antarctic Division participate in CCAMLR and information arising from Australian research has been the basis for Conservation Measures adopted by the Commission.

The environment of Antarctica is now the major issue of concern for the Antarctic Treaty System. Australia will continue to play a significant role in international Antarctic forums to argue for greater environmental protection for the region.

Martin Riddle,
Human Impacts Research Program Leader, AAD

Thirty-year-old eggs may be of historic interest but now strict guidelines are in place to ensure poultry products are not taken into the field because of concerns about introduced disease.

Ian Snape

Australia prioritises environment protection

The AAD's Environmental Management and Audit Unit (EMAU) is responsible for developing measures to fulfil Australia's obligations under the Madrid Protocol, and ensuring that activities in Australia's Antarctic and subantarctic territories are conducted with minimal environmental impact.

Members of the EMAU were part of the Australian delegation led by AAD Director Dr Tony Press, to the 4th meeting of the Antarctic Treaty System's Committee for Environmental Protection (CEP), held in the Hague in September 2000. Outcomes for Australia at the CEP include the acceptance by Treaty Parties of the revised plan of management for Site of Special Scientific Interest (SSSI) No. 17 on the Clark Peninsula near Casey. Collapsing ice cliffs had required that the SSSI boundary be moved to accommodate a new and safer vehicle route, and this in turn required that the management plan be revised and resubmitted through the CEP to the Antarctic Treaty Consultative Meeting.

The CEP has adopted the practice of establishing intersessional contact groups (ICG) on issues which are too large or complex to advance during the Committee's one week meeting, but which demand continuing attention. The CEP endorsed the ongoing leadership by Australia of the intersessional contact group on introduced diseases, and established new groups, in which Australia is a participant, to address several other issues. An ICG on Specially Protected Species, led by Argentina, is assessing the need for a level of protection for Antarctic wildlife above that afforded by the general provisions of the Madrid Protocol. It will also look at criteria which might be used to select species for inclusion for additional protection, and how this might practically be provided.

Another ICG will examine Initial Environmental Evaluations (IEE) across a range of activities prepared by participating Parties. For several years CEP members have been grappling with the problems inherent in addressing requirements of the Madrid Protocol environmental impact assessment, particularly the interpretation of terms used to describe environmental impacts (eg "minor" and "transitory"), and the way in which the various national approaches of the 46 Treaty Parties might be reconciled and benchmarked. The ICG's work will include examining the way in which the various aspects of activities were defined and assessed, and how the final determination of impact was made.

Some details of the CEP's work and an archive of its meeting agendas and papers are available on its website at http://www.npolar.no/cep The next CEP meeting is scheduled for late July in St Petersburg, Russia.

A staff member from the AAD's EMAU spent several weeks this summer at the Larsemann Hills, south of Davis, gathering information and testing proposed management measures for a management plan for an Antarctic Specially Managed Area. The plan is being compiled in conjunction with our Chinese and Russian counterparts, who also operate in the area (Zhong Shan and Progress stations). The project also included familiarisation visits by Chinese and Russian expedition personnel to Davis station, rubbish removal, and developing on-site management links between staff at Davis, Zhong Shan, and Progress.

Scientists and expeditioners from China's Zhong Shan station and Russia's Progress II station celebrate Australia Day 2001 at Australia's Law Base in the Larsemann Hills. AAD Environment Officer Ewan McIvor at back left. Ewan McIvor

In February the AAD commenced a project to establish an Environmental Management System for its activities in Antarctica and Australia. The EMS project is expected to take a year to develop to the point of certication to the Australian Standard, AS14001, and will be supported by environmental consultants with EMS expertise.

The EMAU is also responsible for managing Australia's Antarctic cultural heritage, the Cultural Heritage Officer has produced a draft cultural heritage management and conservation plan for the ANARE site at Atlas Cove, on Heard Island. Similar plans are in preparation for Macquarie Island, in partnership with the Tasmanian government, and for the abandoned Antarctic station Wilkes, near Casey.

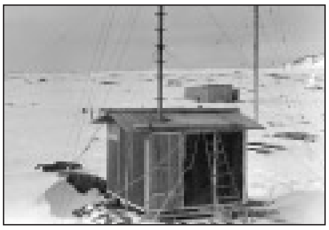
The AAD has arranged with the Queen Victoria Museum (Launceston, Tasmania) to provide a home for a redundant original ANARE building which the AAD plans to remove from Mawson station. The building was designed in 1949 by the Australian Department of Works and Housing and originally erected on Heard Island, before being dismantled and re-erected at Mawson in 1955, where it served in turn as a Meteorology Office, a Biology laboratory and a technical workshop.

Tom Maggs, EMAU Manager, AAD

Every Australian needs a shed!

1948 Construction of 14-sided 5.6m diameter huts for radio/meteorological hut. These buildings were to prove technically successful but they are reported as having a rather depressing atmosphere.

Alan Campbell Drury;

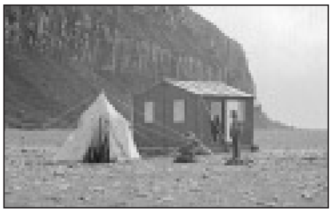


1948 *Borden RAAF hut clad in masonite prefabricated panel construction, uninsulated, designed for the tropics. One of these buildings remains at Atlas Cove in 2001. The tractor garage can be seen over the top of the Dynes hut.*

Alan Campbell Drury

1950 ANARE Mark 1 being erected at Heard Island. It is now the Met/Tech hut at Mawson and proposed to be returned to Australia.

Les Gibbney



1951 Absolute Magnetic Hut at West Bay, Heard Island. This hut is now at Mawson and is still being used for magnetic absolute observations. Bob Dingle

Huts erected by the first Australian National Antarctic Research Expedition (ANARE) to Heard Island in 1947 were soon to prove inadequate for the harsh conditions. This led to innovative approaches to hut design and a string of developments for building design in Antarctica. The hastily organised expedition to Heard Island in 1947 initially utilised Second World War surplus supplies. It was realised that there was a need for much better and more reliable huts.

In 1947 there were two types of huts deployed at Atlas Cove along side the Admiralty hut originally erected in 1927. One type was the fourteen-sided plywood sandwich panel with fibre-glass insulation, often referred to as Alaskan huts. The other type was the ex-Royal Australian Air Force Borden prefabricated hut externally lined with masonite and with no insulation. The Borden huts had been designed for the tropics with ventilation panels at the top and bottom of the wall panels. To these two basic prefabricated building types there were a number of tailored extensions, adaptations, and even whole huts constructed from packing cases or scrounged, salvaged and recycled material at Heard Island. The various cold porches and the D-4 Tractor garage are two examples.

In 1950, 1951 and 1953, following a major development in building technology of prefabricated insulated huts, new huts were placed at Heard and Macquarie Islands. These reflected the need to have reliable, convenient huts that were easy to transport by boat and land in an amphibious vehicle (DUKW's), quick to erect by unskilled labour, easy to maintain and efficiently insulated.

The breakthrough in design came with the ANARE Mark 1 generally known as the Meteorological, Recreational or Seismic hut. The Mark 1 huts were so successfully insulated that condensation built up in them and a small ventilator had to be devised to overcome the problem. These huts were stress skin plywood with integral isolite insulation panels set in an Oregon timber portal frame structure. They combined the good points of the existing huts—plywood stress skin construction like the 14 sided huts, but a simple building form like the Borden huts. The huts employed refrigeration cool store construction techniques of the time. They measured 3.8m by 7.6m (12ft. by 24 ft.). Mawson expeditioners will recognise these buildings as the Met/Tech and Weddell huts, which were relocated to Mawson from Heard Island in 1955.

The Recreation hut at Heard Island is an ANARE Mark 1 hut and, while it is a little the worse for wear, it is still standing. The Met/Tech hut from Mawson, originally deployed on Heard Island, is proposed to be returned to Australia for future display at Queen Victoria Museum in Launceston.

The ANARE Mark 1 design was further refined in 1951 producing a simpler joint detail, making the panels structural and avoiding the need for a frame. The Absolute Magnetic hut and the Variometer hut at Heard Island are examples of this design. These huts were originally erected at Windy City West Bay, Heard Island.

The major inovation in this design was that the panels became structural and were tongue and grooved together. This technique was subsequently employed in the post tension boxes known as the PTBs which appeared as the ANARE Mark 3 in 1954. This inovation made the hut easier to erect and provided a superior joint in terms of wind, grit, rain and water shedding.

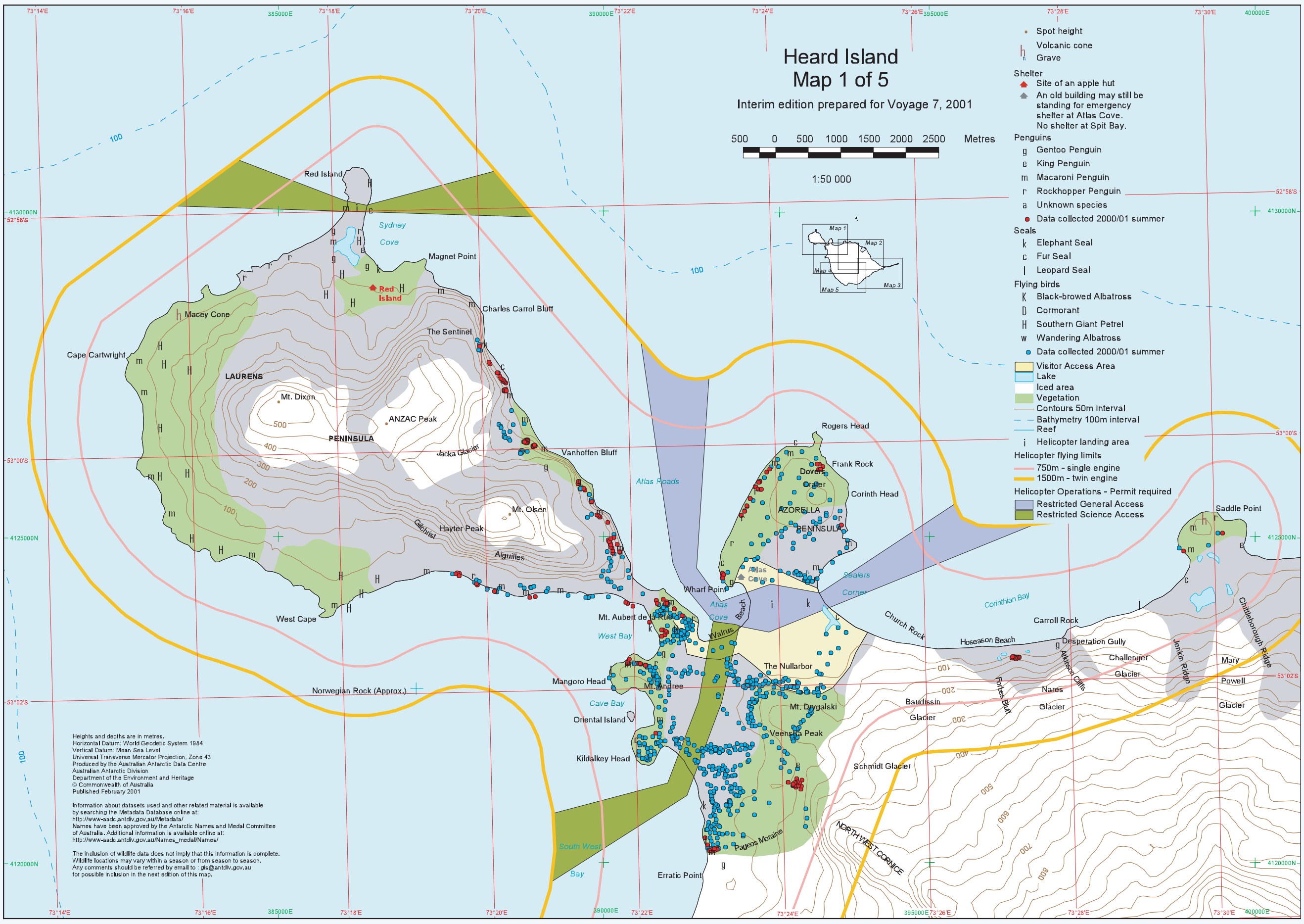
The early buildings that remain provide not just a testament to past activities and operations, but also an opportunity to understand materials performance in these environments. There are important insights to be gained by observation and testing. These buildings certainly provide some surprises to the durability and ecological sustainability of insulated plywood panel constructions in Antarctica. This relatively low level of technological sophistication by today's standards, has outlasted later designs that corroded or failed in the same environments.

The AAD is currently completing an assessment of Atlas Cove Station on Heard Island and this will be available on the AAD's Web site. Further studies are being undertaken into the Macquarie Island Station in the ANARE period and Wilkes Station between 1957-1969. The AAD is interested in comparative assessments and experiences of expeditioners.

If you have a collection of Antarctic expedition diaries or photographs or know of such a collection then Robert Vincent, the Cultural Heritage Manager, would appreciate if you would get in touch with him and make it available for copying by the Division. Alternatively you should consider depositing them in the National or a State Archive.

Robert Vincent can be contacted on phone 03 6232 3424 or email Robert.Vincent@AAD.gov.au

World Heritage listed Heard Island



Australian Antarctic Data Centre

The AAD administers the Territory of Heard Island and the McDonald Islands.

A four-person team visited Heard Island in November 2000 to clean up the derelict buildings and rehabilitate the abandoned ANARE site at Atlas Cove.

The group returned an estimated 25 tonnes of waste to Australia for disposal, some of which had been stockpiled on the beach by a working party which visited the island on a fisheries patrol vessel in February 2000.

The cleanup follows assessments of the site's contaminants and waste types, as well as a thorough heritage assessment which documents the station site's evolution from 1947 to the present.

In January 2001 Senator Hill, Minister for the Environment and Heritage, announced plans to establish a Marine Reserve adjacent to Heard Island.

The reserve, of some 7.6 million hectares, will protect outstanding and representative habitats, geographical features, and terrestrial and marine species and their foraging grounds.

A management plan will be prepared for the marinei area, and the existing World Heritage-listed Heard Island Wilderness Reserve.

Marine debris in the Southern Ocean

Eric Woehler

The quantity of litter or marine debris in the world's oceans has been steadily increasing over the years. This is to be expected, as human populations, industrialisation and sea-traffic, especially fishing, increase. The Southern Ocean is the most remote of seas and even here marine debris is making its mark.

Marine debris is composed mostly of plastic. Estimating its distribution and abundance in the Southern Ocean by direct methods is not practical for a number of reasons. First, the Southern Ocean is vast and the surface concentration of debris is very low. For example, a large surface net was towed behind the RSV *Aurora Australis* for one hundred kilometres, but it caught only surface plankton and a small fragment of seaweed. Second, in the pack-ice zone, such methods are not possible and the ice front and circum-Antarctic currents may act to exclude surface borne materials. The beaches of westward bays (facing the prevailing wind and current direction) of subantarctic islands proved to be the answer.

About 10 years ago studies showed that both Macquarie and Heard Islands had accumulated debris on their beaches. These studies also indicated that the rubbish washed ashore on the two islands was different, and originated from different activities. At that time there was more fisheries litter reaching Heard than Macquarie. Since then the structure of the fisheries has changed.

So how has the beach-washed debris changed, if at all, in these last 10 years? ANARE visits Heard Island infrequently, so the simultaneous visits to both Heard and Macquarie Islands this summer provided the first opportunity in many years to compare the rubbish reaching the two islands. Beaches were searched daily (many of which were surveyed 10 years ago) and the rubbish removed to ensure nothing was counted twice. Weather events, such as storms, were recorded to help determine what influences the amount, distribution and particle-size of the rubbish. By far the greatest component of this litter is plastic. The type and intended use of plastic was determined by analysing its chemical characteristics, and the length of time the material has been in the sea was determined by examining the biological growth and weathering of its surface.

The research confirms that litter is still present in the Southern Ocean and that fisheries are the greatest single source. What is not yet known is whether this is a cause for concern beyond the realisation that the untidy habits of humanity are having their effects even in these most remote of locations. Particles of plastic occur in many carcasses of dead snow petrel chicks found in Antarctica. It is not known whether the plastics contributed to the death of the chicks, how many other Antarctic species are ingesting plastics or whether they are harmful when ingested. Recent research has indicated that small plastic particles may concentrate toxic compounds such as PCBs and pesticides, which could be harmful when ingested. For this reason particular attention is being placed on collecting millimetre-scale plastics on the beaches, in the carcasses of dead seabirds and in the scats of seals. This could explain the occasional high concentrations of these chemicals found previously in some Antarctic species.

Harry Burton & Martin Riddle, AAD

The conservation of Mawson's Huts

Carpenter and heritage specialist examine main hut roof, while materials conservator (foreground) measures moisture content of hut cladding. Rob Easther

A joint venture involving the Federal Government and the AAP Mawson's Huts Foundation completed the third phase of a conservation works program in January 2001 to save the historic huts used by the Australasian Antarctic Expedition (AAE) 1911–14 led by Australia's most acclaimed Antarctic scientist and hero, Sir Douglas Mawson.

From the huts that comprised the winter quarters, sledging parties ranged south, east and west during 1912 exploring and mapping territory previously unknown. The success of the AAE's scientific program laid the foundation for Mawson's later British, Australian and New Zealand Antarctic Research Expedition conducted over two summers between 1929–31 when territorial claims to Antarctica were made in the name of the British monarch. These claims were subsequently handed over to the Australian government and are the origins of its current Antarctic program.

Mawson's own sledging journey ended in disaster and almost cost him his life when his two companions, Ninnis and Mertz, died in separate incidents leaving him to struggle alone the 160 kilometres to the huts at Cape Denison. Arriving a month after the death of Mertz, in a shocking state of starvation and exposure, Mawson was forced to remain in Antarctica for another year with six colleagues left behind to search for his sledging party.

The ship *Aurora* had departed only hours before Mawson's arrival at the huts, the Master, Captain John K Davis, having waited longer than was prudent to collect the other party of the AAE hundreds of kilometres west on the Shackleton Ice Shelf. Although a message reached Davis as the *Aurora* steamed away and he returned to collect Mawson and the rescue party, the notorious weather of Cape Denison intervened and Davis was forced to make the difficult decision to leave Mawson's party and make for the more vulnerable western party which he successfully retrieved three weeks later. The *Aurora* returned a year later for Mawson and his men.

The main living hut, and outposted smaller huts used by members of the expedition for a variety of scientific measurements, remain at Cape Denison despite little attention in the 90 years in which they have endured the most demanding of climatic conditions. Nestled into the landscape, they are a symbol of Australia's earliest Antarctic expedition and unique examples of the few remaining wooden huts used by explorers of the Heroic Era of Antarctic exploration. Although seen by very few people, they are the nation's richest Antarctic heritage buildings. That they have survived, is a tribute to their design and construction, completed as it was by young scientists with negligible practical building experience.

Working in partnership with the Australian Antarctic Division which is responsible for management of the Historic Site, and the Australian Heritage Commission, the Foundation has conducted three expeditions and commissioned a conservation management plan for the site.

The latest expedition returned to Hobart in mid-January after a successful stay at Cape Denison during which all of the waste from several previous expeditions was removed, repairs and maintenance to the huts carried out, and an archaeological survey and environmental monitoring program achieved.

Rusty fuel drums, gas cylinders, old ration packs dating back to the 1960s, camping gear and two cargo containers and their contents were transferred to the relief ship *Sir Hubert Wilkins* and transported to Australia for disposal. Planned repairs to the internal roof of the workshop section of the winter quarters were found to be unneccesary after excavation of the accumulated snow and ice of the past 23 years revealed that the new external cladding on the roof installed by the Foundation's 1997, expedition, had stabilised the structure of the workshop roof and made the potentially disruptive collar tie and rafter replacement work redundant.

The new workshop roof remained drift free during a blizzard experienced by the latest expedition, in contrast to the main living hut roof which allowed considerable ingress of snow during the same blizzard. Despite the substantial repair work completed by the 1997 group which included skylights and ridge capping, more than 180 kgs of snow and ice had entered this section of the hut in the intervening three years.

Uncovered for the first time since Mawson left the huts was the hatch that leads to the under floor space where frozen meat and other produce was stored. Although it was not possible to open the hatch due to the risk of damaging it, small inspection holes were drilled confirming that the area under the floor is solid ice as expected from repeated thawing and re-freezing over the past 90 years. The stability provided by the presence of ice under the floor and the solid wall of permanent ice two metres thick that fills the verandah on three sides of the main living hut and workshop, means the huts are remarkably stable as measurements by the 1997 group proved. They revealed that the internal dimensions and stability of the winter quarters has remained as exact as the day it was completed.

The longer term management and conservation of the historic huts is about to be decided as the government agencies and the Foundation wrap up the Conservation Management Plan which has just concluded a two month period of public consultation.

The most controversial issue surrounding the conservation of the huts has been whether or not the large amount of snow and ice inside the main living hut (about 60% of the space) and adjoining workshop should be removed. Concern for the artefacts inside (if the relative humidity and temperature are changed by the removal of snow and ice) and potential risks to the structural stability of the huts are important considerations that have greatly restricted the options for returning the huts to their former condition.

But the environmental data (collected by electronic monitoring equipment over the past three years), the work of the last two expeditions and observations by heritage building specialists Godden Mackay Logan, and the carpenters and architects employed by the Foundation, suggest that the internal space should be excavated to expose the many artefacts of the AAE thought to be entombed in the ice and not seen since 1931 when Mawson last visited. Replacing the wooden battens that Mawson's men tacked on the joints of the tongue and groove Baltic Pine timber on the roof (which have mostly blown away) would significantly reduce the ingress of snow and ice into the space. Such action would reveal the full extent of the winter quarters, and allow visitors to appreciate the full spirit of this extraordinary place.

Rob Easther, Expedition Leader, AAP Mawson's Huts Foundation & Field Operations Manager, AAD

Interior of the main hut showing ice accumulation surrounding bunks and storage platform. In the left foreground is the acetylene plant used for lighting. Rob Easther

Flies discovered at Casey station

In March 1999 a tray of chicken eggs delivered to Casey Station, was found to be infested with numerous larvae, pupae, empty puparia and adults of a small fly. The infestation was discovered on 10th March when the container was opened outside the Green Store. There was a noticeable smell of decomposing food. The infested boxes of eggs were therefore immediately moved to the Emergency Vehicle Shed (EVS), to avoid contamination of food already in the Green Shed. Upon opening the boxes in the EVS, some of the eggs were found to be cracked and to have gone bad. Trays with obvious fly infestations were immediately transferred to the incinerator building, A few days later they were all burnt. In order to ensure the EVS was free of any escaped flies, the heating was turned off for seven days. The ambient temperature was between -5 and -13°C during this period. Following incineration of the eggs, the incinerator building was subjected to the same treatment.

The flies were identified as Phoridae and a sample was eventually handed to Henry Disney, who identified them as *Megaselia scalaris* (Loew). This fly is primarily a species of warm climates; but it is best known as an infamous tramp species that has been transported around the world by man, mainly in ship cargoes. Adults have also been reported being carried 800 km in an aeroplane and being transported from North Africa to Spain in the plumage of a migrating bird.

The larvae of this species have been frequently reported contaminating foods such as pastas, dates, soya flour, cheese, dried fish and rotting potatoes. The species is noted for its catholicity in the choice of suitable food for breeding. Decaying plants and fungi, dead arthropods and molluscs are typical; but human faeces and corpses, shoe polish and even a tin of blue paint (the phthalocyanine blue being the most likely energy source) are also recorded being exploited by the larvae. Females, attracted by the smell of decay, can insert their eggs through the smallest openings and first instar larvae have even been reported entering turtle eggs through the larger pores of the shell.

Exposed foods may attract egg-laying flies. The subsequent accidental ingestion of eggs can then cause intestinal myiasis, with third instar larvae being passed in the patient's stools. There are also rarer reports of larvae infesting wounds, the urogenital tract and the nasal sinuses.

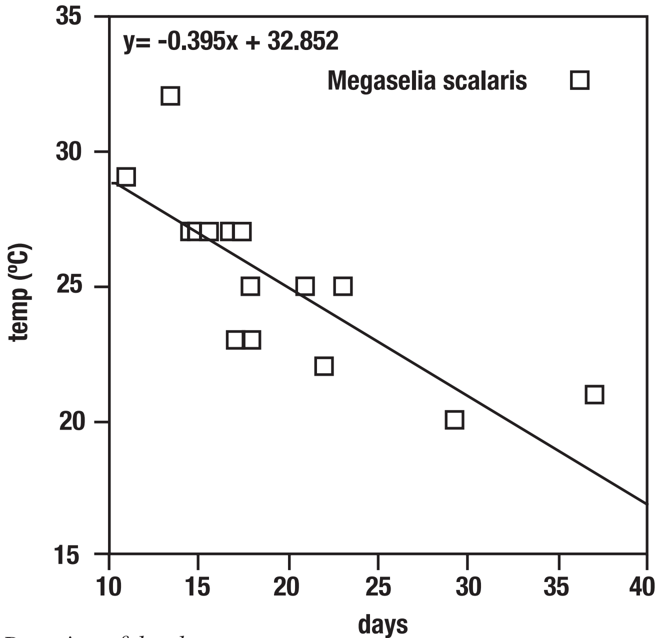
The duration of the development of the fly varies with temperature (see figure). There are no authenticated records of the eggs and first instar larvae withstanding temperatures below 0ºC. However, adults successfully emerged from contaminated food in a Hong Kong freezer compartment at -2 to -3ºC. The lack of records of breeding outdoors in higher latitudes is the principal basis of the inference that the eggs and/or the first instar larvae cannot withstand freezing. Furthermore some data indicate a reduced fecundity at lower temperatures. Typically a female will lay about 30 eggs (range 12-77) in each ovarian cycle. Up to sixteen cycles have been recorded in the laboratory, giving a total fecundity of around 400 eggs per female. However, in one experiment the mean number at 15ºC was reported to be only 146.7 eggs, compared with 591 at 20ºC and 664.8 at 25ºC. The inference that the eggs and/or first instar larvae cannot withstand freezing needs testing before we place too much reliance on freezing as a method of control.

If only the second instar larvae and subsequent stages can withstand frost, then we can speculate as to the origin of the Casey infestation. The chicken eggs had been procured in Perth, but the ship caught fire 10 hours after leaving and had to return to port, where the container was offloaded and left on the wharf for several days. The container was then sent on to Capetown, where it arrived and was transferred to a polar ship on 18 February. The ship arrived at Casey on 8 March.

The scenario with the fewest assumptions is that some cracked eggs went bad while the container was on the wharf at Perth and that flies then oviposited in the container while it was in Capetown, where the species is common in summer. The hatching of the new generation would then be around the time of arrival at Casey.

Peter Nickolls, CSIRO, & Henry Disney
Cambridge University, U.K

Reference:
Disney, R. H. L. (1994) *Scuttle Flies: The Phoridae.* London, Chapman & Hall.



Duration of development (egg to adult) varies with temperature

Antarctic Treaty focusses on environment and liability

Parties to the Antarctic Treaty are expected to meet in Russia in July 2001. High on the agenda will be a range of environmental protection issues, including the outstanding issue of liability for environmental damage.

The 2001 meeting will be the 24th Antarctic Treaty Consultative Meeting (ATCM XXIV) and will incorporate the 4th meeting of the Committee for Environmental Protection (CEP). The previous full ATCM was held in Peru in 1999, and in 2000 a truncated meeting, comprising mainly a meeting of the CEP, was held in The Hague. This year's meeting, to be held in St Petersburg from 9 to 20 July, will continue the work done over the previous two years.

The CEP, which was established by the Protocol on Environmental Protection to the Antarctic Treaty, held its first meeting in 1998 following the entry into force of the Protocol. It's agenda includes matters relating to environmental impact assessment, conservation of Antarctic flora and fauna, waste management, prevention of marine pollution and development of the Antarctic protected area system. The work of the CEP is further described in the story on page 47.

The Parties will also continue negotiations undertaken in Lima on developing rules and procedures relating to liability for environmental damage. This requirement stems from Article 16 of the Protocol which envisages the development of one or more annexes to address this important issue. Discussion of the liability rules commenced in 1993, but the complexity of the issue and the differences of view has led to slow progress.

The Antarctic Treaty parties have put in place many effective measures to protect the Antarctic environment. What would happen if, despite their best efforts, there was an environmental disaster? Fortunately, Antarctica has never seen a maritime accident of the scale of the 1989 *Exxon Valdez* incident in the Arctic, but that does not mean that the Parties are complacent. If someone makes a mess in Antarctica, Parties want it cleaned up and, if it is not, they want rules for deciding who pays and how much. So, on the surface the requirement is straightforward.

In reality it is very much more complex. Experience gained in other international liability agreements shows us that it will not be easy. And in Antarctica the issues are more complex given the jurisdictional situation, the extreme remoteness, the climate which could make clean-up impossible, and the requirement for consensus decision-making in Treaty meetings.

A major sticking point is the question of what the regime should cover. Some Parties favour the so-called comprehensive approach which would cover all circumstances, whereas others prefer to start with a more limited regime—such as one which would provide only for liability for failure to take response action in emergencies.

Australian delegation to the 12th Special Antarctic Treaty Consultative Meeting, The Hague, September 2000.

A Jackson

The 2000 meeting in The Netherlands included an informal exchange of views on the issues and it is expected that the next Treaty meeting will continue the formal negotiations. This will include consideration of a personal proposal from the New Zealand chairman of the discussions who has proposed a framework for development of the liability regime. The proposal provides a structure for a regime which would ultimately be comprehensive in coverage, but which can be developed in stages according to priorities, such as the concern to address responsibility for response action in emergencies. This model is potentially attractive to a number of Parties.

Importantly, the Parties also agreed that COMNAP and SCAR should be asked to provide more technical and scientific input to the discussions so that the outcome of the debate is confident of practical application.

In pursuing its Antarctic policy and legal interests, Australia is pushing hard within the Treaty framework to find creative solutions to this problem so that the outstanding commitment made in the Protocol is finalised. The AAD believes that this is critical to the effectiveness of the Protocol—ultimately the liability rules must provide a strong incentive for operators in the Antarctic to meet their environmental obligations and, if something does go wrong, to ensure that any damage is made good.

Andrew Jackson,
Antarctic Treaty & Government Section Manager, AAD

Antarctic Treaty to celebrate 40 years

The twenty-third of June 2001 marks the 40th anniversary of the entry into force of the Antarctic Treaty. The Treaty provides for the cooperative governance of the region south of 60° South, and now is the cornerstone of the Antarctic Treaty system.

When compared to other international agreements the Antarctic Treaty is modest in length, but that does not reflect its enormous significance and enduring effectiveness as a basis for cooperative management of an entire continent. Since the adoption of the Treaty by 12 states, the number of parties has grown to 44, of which 27 are the Consultative Parties who are entitled to participate in the decision making. But the growth of the Treaty system goes well beyond this.

Since the first Consultative Meeting in Canberra in 1961, the parties have developed a series of increasingly sophisticated and specialised measures which combine to form a regime of great effectiveness for managing activities on the Antarctic continent and in vast regions of the surrounding Southern Ocean.

Apart from the Treaty itself, the system includes the Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR), the Convention for the Conservation of Antarctic Seals and the Protocol on Environmental Protection to the Antarctic Treaty. In addition there is a raft of measures, resolutions and decisions adopted at the annual meetings of the Consultative parties. Also associated are a number of institutions and organisations which undertake specialised work and provide advice to the ATCM.

The year 2001 also sees the 20th annual meeting of CCAMLR (see story opposite on the Convention's achievements) which has been instrumental in managing and protecting the living resources of the Antarctic marine area. Celebration of the 40th anniversary of the Treaty and its achievements since 1961, and the 20th meeting of CCAMLR, will be milestones of the Treaty system in 2001.

CCAMLR continues efforts to protect toothfish

The nineteenth meeting of the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR XIX) took place in Hobart from 23 October to 3 November 2000. Twenty-two of the 23 Members of the Commission were represented, including Australia. Also participating were several States in their capacity as Parties to the Convention on CAMLR, States not Party to the Convention but having an interest in fishing for or trading in Patagonian toothfish, intergovernmental organisations, regional fisheries management organisations and conservation organisations.

An important outcome of CCAMLR XIX was the adoption of further measures to combat illegal, unreported and unregulated (IUU) fishing for Patagonian toothfish. A key element of this was significant improvement to the CCAMLR Catch Documentation Scheme (CDS) for toothfish. This requires all CCAMLR Members, which form about 95% of the global toothfish market, to only accept catches whose origins have been documented under the Scheme.

There have been further improvements in the relationship between CCAMLR and States not party to the Convention but which are involved in harvesting of toothfish in the Convention Area. In this regard the Parties were particularly encouraged by the announcement by the recently elected Mauritian government that it will implement the CDS and is considering denying IUU fishing vessels access to its ports. Mauritius is also considering acceding to CCAMLR. The importance of this is highlighted by CCAMLR estimates that about 50% of IUU caught toothfish taken in 2000 were landed in Mauritius.

Delegates to CCAMLR XIX. Peter Laws

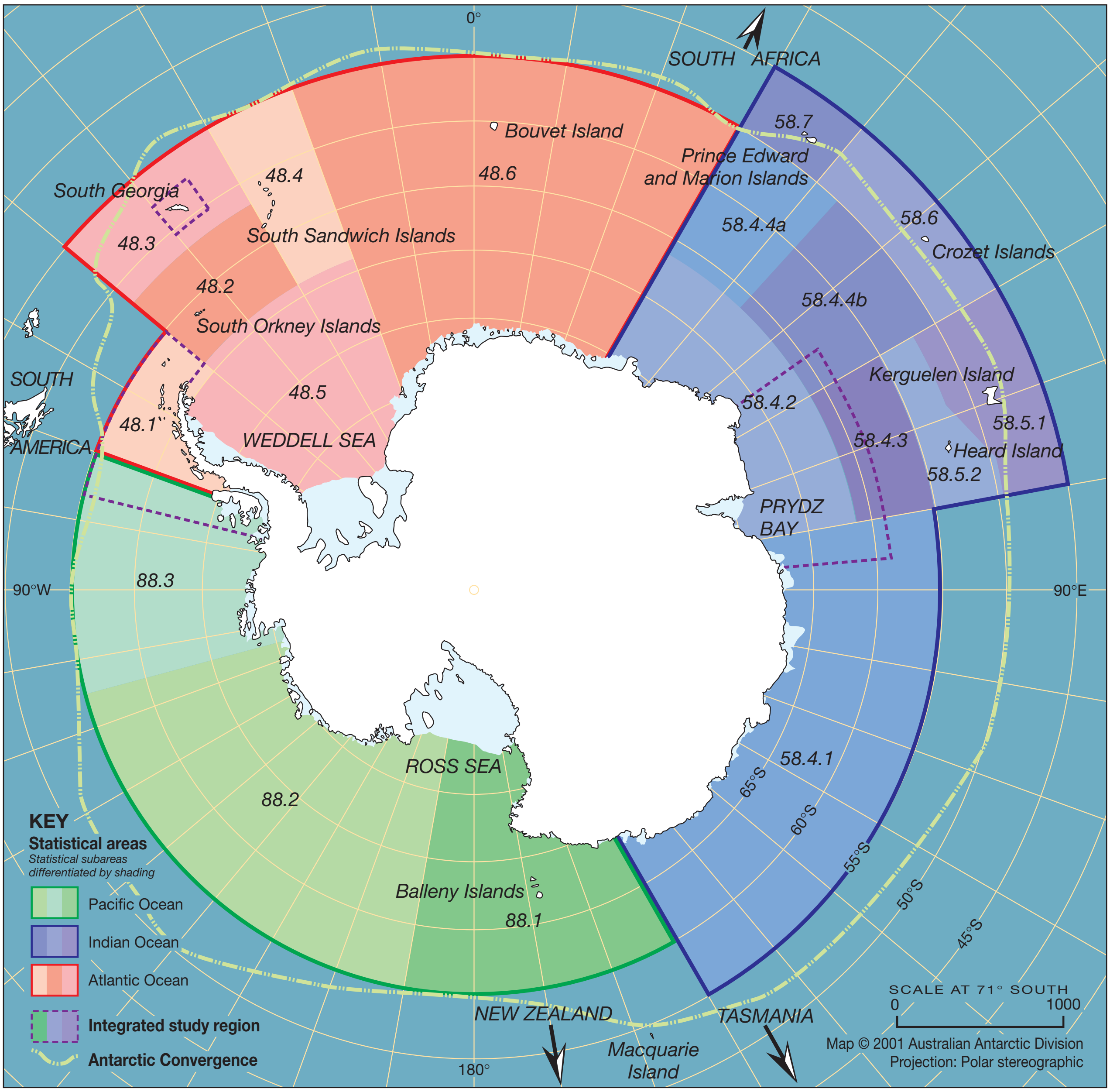
The Parties also welcomed the announcement by Namibia that, as part of its efforts to combat IUU fishing, it has become a Party to the Convention and has closed its ports to IUU fishing vessels.

Other developments at CCAMLR saw further support for using a scientifically-based approach to achieve a sensible balance between conservation and rational use. This includes the adoption of measures that require fishers undertaking exploratory fishing to also undertake research to gather the data needed for future management of the fishery. There was also agreement, following several years of zero real growth, to increased funding for the extensive work program set by CCAMLR for its permanent Secretariat, headquartered in Hobart.

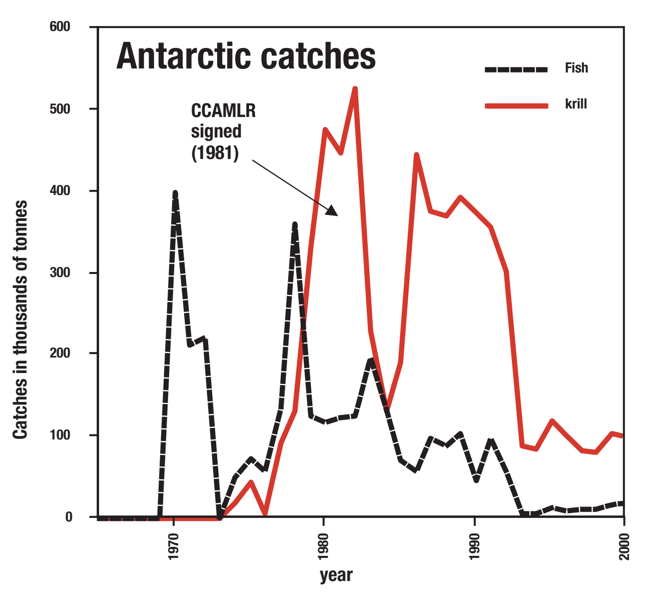
CCAMLR will continue its work to conserve the living marine resources of the Southern Ocean when it meets again in Hobart later this year. The twentieth meetings are scheduled for 29 October to 9 November 2001.

Ian Hay, Senior Policy Officer, AAD

CCAMLR: the first twenty years



The Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) has met annually since 1982 and is tasked with implementing the Convention on the Conservation of Antarctic Marine Living Resources; the agreement which was designed to conserve fish, squid, krill and other living resources in the Southern Ocean. Over the last 20 years CCAMLR has passed through a number of phases as the Commission and its Scientific Committee have come to terms with different concepts and developments. In the initial years, 1982 to 1990, the Commission was very much finding its feet, developing procedures to manage the fisheries of the region and coping with a number of fisheries which had been seriously depleted before the Convention was signed. In the late 1980s and early 1990s there was a flurry of activity as the Commission came to terms with a management approach to its largest fishery—that for Antarctic krill. Since the middle 1990s there has been an increasing focus on developing mechanisms for managing harvesting of Patagonian toothfish, including dealing with illegal, unregulated and unreported fishing. As the 21st century began, with most of the region's fisheries operating under at least one CCAMLR Conservation Measure, there is a renewed focus on krill and on the ecosystem approach to management. Underlying these changes have been political and economic undercurrents such as the demise of the Soviet Union, once the region's largest fishing nation; the depletion of many of the rest of the world's largest fish stocks and the consequent oversupply of



deep sea fishing vessels; and the massive growth in aquaculture, which may underpin the next wave of Antarctic exploitation as new sources of fish feed are sought. Antarctica may be the most isolated continent but the fisheries of the region are driven by forces external to the region.

The Convention arose out of two major concerns. Firstly at the time of negotiation the krill fishery was expanding and was seen as a potentially very large fishery. There was a concern amongst the negotiating parties that pre-emptive management could avoid the pattern of overexploitation which had characterised seal, whale and fish exploitation in the Antarctic. There was also major concern that since krill was a key animal in the Antarctic, harvesting of krill should proceed in such a way so as not to adversely affect the ecosystems dependent on it, and in particular should not hinder the recovery of baleen whales. Secondly, some of the fish species of the Antarctic region were or had already been exploited heavily, and since these were unprotected by any fishing regulations, some mechanism was necessary to ensure that further harvesting of fish proceeded in a rational fashion. CCAMLR broke new ground in its espousal of an ecosystem approach to management, which is enshrined in Article 2 of the Convention.

This was one of the first formalisations of the principles of what has become known as Ecological Sustainable Development (ESD). The effects of the fisheries on species other than those targeted have to be taken into account. Much of the recent work of CCAMLR has been driven by this imperative rather than by the more mundane setting of isolated allowable catches as has been the case in most other fisheries. The focus on the krill fishery has resulted from fears about the effects that a large harvest might have on krill predators rather than on the krill stocks themselves. In the case of the illegal fishing for Patagonian toothfish, in addition to concerns about depletion of the species, a major concern of CCAMLR has been the huge bycatch of endangered albatrosses on the long-lines of the illegal fishers. CCAMLR has had to develop a number of new methods and procedures to come to grips with the requirements of Article 2 and in doing so has put itself at the forefront of marine resource management.

Currently the fisheries in the Convention area are at fairly low levels. Around 20,000 tonnes of fish and around 100,000 tonnes of krill are legally caught each year. Some squid and crabs are also caught. It seems unlikely that the fish catch is going to increase markedly because stocks are relatively small and most stocks are either being exploited or are recovering from earlier exploitation. Squid may be a resource of the future but there is considerable uncertainty about the size of the stocks. Antarctic krill remains the largest exploitable stock and its exploitation also poses the greatest threat to the ecosystem. The current precautionary catch limit on krill is just over 5 million tonnes per year and this is calculated as a sustainable catch that takes into account the needs of the myriad vertebrates that feed on krill. It is likely that the krill fishery will expand in the near future to provide feed for a globally burgeoning aquaculture industry. A challenge for CCAMLR in the future will be to ensure that this huge potential catch is distributed in a way that does not adversely affect the populations of land-based krill feeding seals and seabirds. Managing large fisheries in international waters is fraught with difficulties and given the mandate of CCAMLR to use an ecosystem approach this makes the task difficult, both administratively and scientifically. The first 20 years of CCAMLR has provided a good foundation for the work that lies ahead but the task that was designed into the Convention will provide many diplomatic, administrative, scientific and practical problems for the years that lie ahead.

Stephen Nicol, Antarctic Marine Science Program Leader, AAD

Article II.

1. The objective of this Convention is the conservation of Antarctic marine living resources.

2. For the purposes of this Convention, the term “conservation” includes rational use.

3. Any harvesting and associated activities in the area to which this Convention applies shall be conducted in accordance with the provisions of this Convention and with the following principles of conservation:

(a) prevention of decrease in the size of any harvested population to levels below those which ensure its stable recruitment. For this purpose its size should not be allowed to fall below a level close to that which ensures the greatest net annual increment;

(b) maintenance of the ecological relationships between harvested, dependent and related populations of Antarctic marine living resources and the restoration of depleted populations to the levels defined in sub-paragraph (a) above; and

(c) prevention of changes or minimisation of the risk of changes in the marine ecosystem which are not potentially reversible over two or three decades, taking into account the state of available knowledge of the direct and indirect impact of harvesting, the effect of introduction of alien species, the effects of associated activities on the marine ecosystem and the effects of environmental changes, with the aim of making possible the sustained conservation of Antarctic marine resources.

Increased diversity of private expeditions poses challenge

Martin Betts

The 2000-01 summer season saw continued growth in tourism and non-government activity in Antarctica. More companies became involved, with a wider range of activities, and private adventurers pushed further afield. Some companies provided mountaineering, skiing, hiking and other opportunities in the Peninsula region, and at least two companies offered overnight stays ashore. Kayaking has become a part of some itineraries, while SCUBA diving was also offered.

In reponse to market demand, tour companies are considering further expansion of their on-shore activities in 2001-02 and, if the trend continues, increasing pressures on land use is inevitable. As yet there appear to be no plans to establish permanent on-shore accommodation, but this cannot be ruled out in the future.

Concerns have been expressed that the annual creep in the extent, range, and diversity of Antarctic tourist and adventure activities may outstrip the land management practices developed by the Antarctic Treaty System (ATS) over the past forty years to deal with them, particularly in the Antarctic Peninsula area. While the present situation is not critical, little of the work currently under way within the ATS is focussed on the regional-scale issues involved, and experiences in other parts of the world suggest that there is the potential to cause problems in later decades if the issues are not addressed.

While the ATS has specific arrangements to deal with relatively small areas under the Protected Area System, no broad-scale land management practices capable of dealing with increasing extent and diversity of land-based recreational activity have been developed.

Traditionally, ship and yacht operators have supported relatively brief shore visits to continental and island sites. People going ashore were generally only able to visit relatively small areas, a practice that has given rise to various studies on individual site characteristics and potential cumulative impacts. More recently, however, as companies work to develop market specialisation and adventurers seek novel challenges, the type and distribution of activities has diversified markedly.

While it appears that such activities are being conducted responsibly, the companies involved plan their activities independently. To avoid conflicts between activities, and to minimise the potential environmental impacts, a more coordinated regional approach is likely to become necessary. Researchers from a number of nations are examining the effects on individual species of human disturbance and work has commenced on studying the potential cumulative impacts of tourism. The challenge for the ATS (particularly the CEP) is to be prepared to meet the growth of non-government interest in the Antarctic with timely and effective environment protection strategies.

Martin Betts, Senior Policy Officer, AAD

Come fly with me over the Antarctic

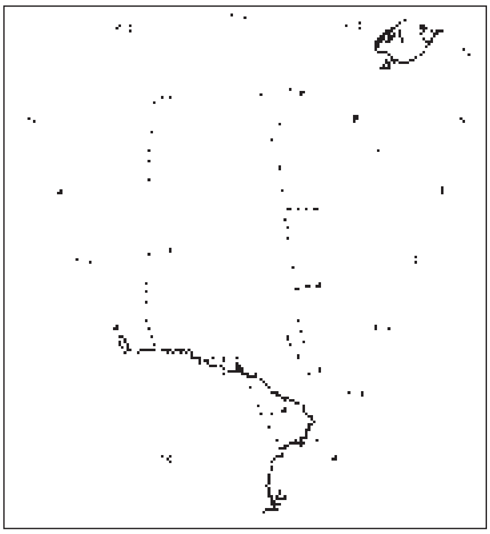
The Transantarctic Mountains as seen from a recent Qantas Boeing 747–400 tourist flight. The Ross Sea (covered in sea ice) is visible on the right hand side of the photo adjacent to the second engine cowling. Mike Ball

Each summer up to around ten tourists flights (using Boeing 747–400 aircraft chartered from Qantas by Croyden Travel) depart from Sydney, Melbourne, or Adelaide, and sometimes Perth, with the aim of seeing the magnificent views which the Antarctic has to offer. Figure 1 shows a flight path for such a sortie: the aircraft leaves Sydney at about 8 am DST (2100 UTC), reaches 50º S at about 10 a.m. (2300 UTC), and the Cape Adare area at around 12.20 p.m. (0140 UTC). The route shown on this example sees the plane then fly westwards along the coast to depart the Antarctic Continent over Dumont d'Urville at around 3 p.m. (04000 UTC). The actual route depends on the viewing conditions: on another day the flight might firstly fly over the Dumont d'Urville area then head towards the Transantarctic Mountains which are a very popular target *(above)*.

The success of these flights depends critically on the viewing conditions, in other words on the presence or otherwise of cloud. The Bureau of Meteorology plays a vital role in providing the flight pilot with information and forecasts which enable him or her to over-fly the least cloudy viewing regions. The forecast information is provided by the Australian Bureau of Meteorology Regional Forecasting Centre in Hobart, Tasmania, Australia or by Antarctic Meteorological Centre at Casey (when staffed). Typically an experienced Antarctic weather forecaster will be assigned to a particular flight. On a Friday evening they will prepare a preliminary outlook for the flight which will take place the following Sunday. This outlook will be in general terms giving a general idea of where the best viewing conditions might be. Overnight Saturday night-Sunday morning this forecaster will be back on-deck producing detailed forecasts of route-winds, weather, and, in particular, cloud conditions.

The relevant forecast products are generally compiled using the best Numerical Weather Prediction (NWP) computer models available globally and are complemented by satellite imagery obtained from the polar orbiting and geostationary meteorological satellites. In keeping with state-of-the art communications Qantas Operations are able to download the forecasts from their web site: this usually happens a few hours prior to the estimated flight departure time. Communications and the Bureau of Meteorology next play a vital role as the aircraft is approaching the Antarctic Coast: the pilot rings the Bureau for any updates in the information, and is usually able to fine-tune the flight path to maximise the viewing time of Antarctic features. Generally a splendid time is had by all and most flights provide wonderful visual experiences for the passengers, even hard-bitten Antarctic expeditioners who have seen it all before.

Steve Pendlebury, Neil Adams, and Mike Ball, Bureau of Meteorology



Route sector map for Antarctic tourist flight taken on 22-23 February 2000. (Times are UTC).

Antarctic weather records: Mawson station

EACH ISSUE WE WILL WE BRING YOU HIGHLIGHTS OF the recent weather experienced at Australia's Antarctic stations. We thought that we'd start with Mawson station being, as it were, the western outpost, and the continental station (excluding the Antarctic Peninsula) with the longest continuous meteorological record. Next issue we'll move to Davis station.

Extremes for the year 2000

Highest Air Pressure	1015.4 hPa, 1st September
Lowest Air Pressure	953.1 hPa, 12th October
Highest Minimum Temperature	-00.6°C, 22 December
Lowest Minimum Temperature	-28.3°C, 18th May
Lowest Maximum Temperature	-22.5°C, 15th May
Highest Maximum Temperature	03.8°C, 30th December
Highest Maximum wind gust	SE @ 108 knots (200kph) at 02:08, 24th May

Weather phenomena

Mawson is a dry but windy place as can be seen from the wind and snow data for 2000. There were 98 continuous days of strong wind (ie 22 knots or greater) between January 30th and April 5th 2000. The record is 101 days between 21st May and 29th August in 1967.

	No. of Days	% of the year
Strong Wind (= >22 knots)	340	93
Gales (= >34 knots)	196	54
Blizzard	32	9
Snow fall	49	13
Blowing snow (=< 1km)	58	16

A blizzard is defined as a period of > one hour when the visibility is reduced below 100 m by blowing snow, the temperature is < 0°C and the wind speed is > 33 kts.

GLENN JACOBSON

WAYNE PAPPS

Records created in 2000

The following are the month by month extremes observed in 2000 which have been unmatched since February 1954 when records began. The values in brackets are the previous record value. In most of the months not mentioned there were values of one or more parameters which equalled a previous record.

January
Lowest 9am average Station Level Pressure:
978.9 hPa (982.1 hPa in '91)
Lowest 3pm average Station Level Pressure:
979.5 hPa (982.8 hPa in '71 & '91)
Most blizzard days for the month:
3 days (2 in '59, '62, '86, & '97)

February
Most strong wind days (note: 2000 is a leap year):
29 (28 in '56, '66,' 71,' 76, '86, & '91)

March
Windiest March, average wind-speed:
54.2 kph (51.2 kph in '96)

April
Windiest April, average wind-speed:
56.9 kph (55.1 kph '91)

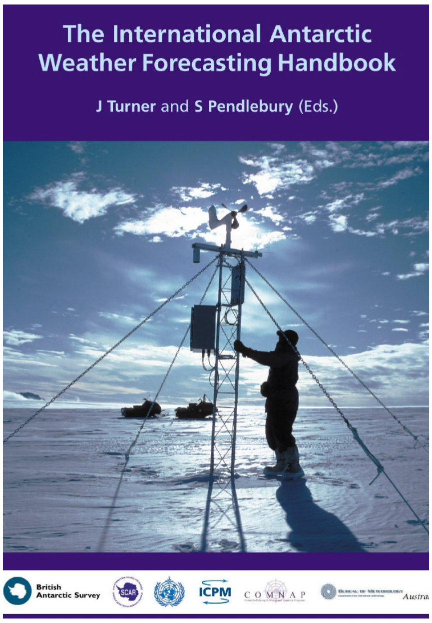
May
Days of blizzard for the month:
7 (6 days in '69 & '99)

June
Days of blizzard most per month for the year:
23 (19 days in '68)

October
Most hours of sunshine for an October:
380.2 hrs. (310 hrs in '84)
Lowest maximum temperature for an October:
-8.1ºC (Minus 7.5 in '91)

Steve Pendlebury, Bureau of Meteorology, Hobart
Data contributed by Max Walsh, Senior Observer at Mawson for 2000.

In Brief…



Although weather forecasts have been issued for various parts of the Antarctic since the early expeditions, there has not been a great deal of international cooperation regarding the dissemination of knowledge about forecasting techniques. A number of nations have produced forecasting handbooks for their areas of operation but these have often not been widely disseminated. To try and aid the exchange of information on forecasting the First International Symposium on Operational Weather Forecasting in the Antarctic was held in Hobart, Australia between 31 August and 3 September 1998. This meeting brought together participants from eight nations, who included forecasters, administrators, users of forecasts and researchers with an interest in the development of improved forecasting techniques. One of the major outcomes of the meeting was the decision to prepare *The International Antarctic Weather Forecasting Handbook*, which was seen as a good way of providing a reference volume of material on forecasting methods used in the Antarctic. The handbook has now been prepared under the auspices of the British Antarctic Survey, the Australian Bureau of Meteorology, the Scientific Committee on Antarctic Research, the World Meteorological Organisation, the International Commission on Polar Meteorology and the Council of Managers of National Antarctic Programs.

The handbook consists of two parts. The first provides information on the physical characteristics of the continent, the nature of high latitude weather systems, the forecasting requirement, analysis and forecasting techniques used in the Antarctic and the means by which specific elements are forecast. The second part described forecasting techniques used at specific locations across the Antarctic.

The handbook is now at version 1.1 and consists of nearly 700 pages of information on all aspects of forecasting in the Antarctic. It is available for download from the British Antarctic Survey FTP site at: http://www.nerc-bas.ac.uk/public/icd/jtu/ftpinst.html and through the Operations/Meteorology links at the Council of Managers of National Antarctic Programs (COMNAP) site at http://www.comnap.aq/comnap/comnap.nsf

John Turner (British Antarctic Survey) & Steve Pendlebury (Australian Bureau of Meteorology)

The Australian Antarctic Foundation Subantarctic Plant House

In the great Southern Ocean, approximately 1500 km southeast of Tasmania, lies a small island few people will ever have the opportunity to visit. Known as Macquarie Island, this relatively young landmass emerged approximately 600,000 years ago as a piece of deep ocean crust thrust above sea level by massive continental plate activity.

The Australian Antarctic Foundation Subantarctic Plant House was opened on October the 13th, 2000 by Sir Ninian Stephens in his capacity as the former chairman of the Australian Antarctic Foundation. The Subantarctic Plant House at the Royal Tasmanian Botanical Gardens displays the unique flora of Macquarie Island against a panoramic mural of the area. Painted by renowned Tasmanian artist, John Lendis, the mural reflects the rugged terrain and bleak beauty of the island and its vegetation.

The project is a world first, being the first purpose-built display environment designed to grow the flora of a subantarctic island. Measuring 14 x 6 metres the House is designed in the shape of a tear drop, with high curving walls and a clear polycarbonate roof. Internally it is cooled by piped cold water, air conditioning and a misting unit.

Visitors will not only have the opportunity to learn about the unique flora of the Island but will gain a better understanding of what it actually feels like to be there, as the cold, wet and windy conditions have been recreated in the Subantarctic Plant House with the aid of a fogging system and fan-driven chiller unit.

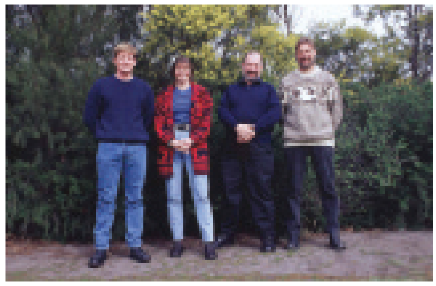
Display plants include *Poa foliosa*, a grass tussock which can reach two metres in height and is the dominant plant on the island, and the two mega-herbs:the famous Macquarie Island Cabbage, *Stilbocarpa polaris*, which was used against scurvy by whalers of yesteryear and a large silver grey leafed member of the daisy family, *Pleurophyllum hookeri*. Other species may look familiar including cushion plants *Azorella macquariensis* and *Colobanthus sp.*, grasses *Festuca contracta* and *Agrostis sp.*, and the fern *Polystichum vestitum*. The common buzzy *Acaena sp.*, whose seed heads stick to our socks, also grows on Macquarie Island. The buttercup family is represented in the form of *Ranunculus crassipes*. The Heard Island plant, *Pringlea antiscorbutica* will also be on display.

The house has been largely funded through the generosity of the Australian Antarctic Foundation as the major sponsor with significant contributions from a number of other Tasmanian businesses. The development of the house has been greatly facilitated by valuable assistance from scientists and staff from the University of Queensland, The Australian Antarctic Division and Tasmanian Parks and Wildlife.

ROYAL TASMANIAN BOTANICAL GARDENS

As the newest plant display at the Botanical Gardens, the Subantarctic Plant House provides a fascinating glimpse of plant life on Macquarie Island and for most people it will be their only opportunity to experience first-hand the subantarctic flora of 'under, down under'.

Mark Fountain,
Royal Tasmanian Botanical Gardens



(from left) Robb Clifton (Macquarie Island), Meg Dugdale (Mawson), Paul Cullen (Casey) and Jeremy Smith (Davis). GLENN JACOBSON

Station Leaders for 2001

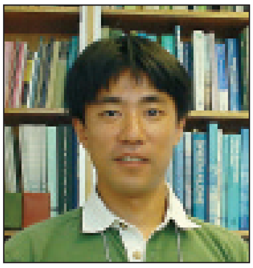
A university professor, two Army officers and an executive chef have been selected to lead teams of scientists and support staff at Australia's three continental Antarctic stations at Mawson, Davis and Casey and on subantarctic Macquarie Island. They will spend the winter of 2001, the fifty-fourth year of Australia's modern Antarctic program, in charge of between 15 and 20 men and women at Australia's isolated Antarctic outposts.

Jeremy Smith is an Associate Professor in Biogeography at the University of New England at Armidale, NSW. He was the Station Leader at Macquarie Island in 1996 and this time will go to Davis, the busiest station for Australia's antarctic scientific research program.

Meg Dugdale, Station Leader for Mawson, is on leave from the Australian Army where she was until recently a Visiting Military Fellow at the Australian Defence Force Academy and a Senior Instructor at the Australian Technical Staff Wing of the Australian Command and Staff College. A communications engineer with a Masters in International Relations, her military service includes command of a contingent of 117 combined services personnel in both the UK and Germany.

Paul Cullen has been the Executive Chef at the Hotel Grand Chancellor in Hobart, where he was responsible for all aspects of the catering operation, which included a team of 50 staff. He has some 20 years experience in the hospitality industry and has worked in a range of positions throughout Australia, but his posting to Casey is likely to be the most challenging yet.

Robb Clifton, who will be the station leader for Macquarie Island, has recently returned from climbing Big Ben, the 2745 m active volcano that towers over the remote Australian territory of Heard Island. He has recently left the Australian Army where he served in the Special Air Service Regiment. He has a BSc in Computer Science and is currently studying for a Graduate Diploma in Environmental Management.



HARVEY MARCHANT

Visitors to the AAD

Dr Akira Ishikawa

Australia has strong links with Japan in Antarctic research. Both nations structure their Antarctic programs similarly and over the last fifteen years there has been an increase in the working collaboration between the two. Last year the Australian Antarctic Division (AAD) and the National Institute of Polar Research (NIPR) formally recognized this close association with the signing of a document by the directors of both organisations.

The Japanese biologist who is presently working in the AAD as a visiting scientist is Dr Akira Ishikawa from Mie University. He is on a two year postdoctoral fellowship funded though a bilateral program between the Japanese Society for the Promotion of Science and the Australian Academy of Science. He is working with Harvey Marchant and Graham Hosie to investigate the ecological role of the smallest (but the most abundant) species of phytoplankton in the Antarctic Ocean. He is looking at the interactions between them, their role as food for grazers, and the ways in which grazing influences the community composition of these organisms. This involves participating in marine science voyages (for the 1999–2000 and 2000–01 seasons) as well as experimental studies in the AAD's laboratories.

Akira has received significant recognition early in his career in the form of two awards: the "Okada", a prize from the Oceanographic Society of Japan for excellence in oceanography by a young scientist and the "Shorei-sho" from the Plankton Society of Japan for excellence in research by a young scientist. We are particularly fortunate that such a promising scientist has chosen to work as part of our program

Mr Xiaoliang (Granty) Ling from the Polar Research Institute of China is visiting the Australian Antarctic Data Centre (AADC) in 2001. He will be learning how the AADC operates, and will be briefing us on Antarctic data management activities in China. He will work on a number of data management initiatives in the AADC, the most significant of which will be to assist with the development of an Antarctic Biodiversity Database for the SCAR project, Regional Sensitivity to Climate Change (see articles on p 16 and 17). This database promises to be by far the most complex that the AADC has developed to date.

Antarctic policy studies developed

The policy arm of the Australian Antarctic program is developing strong links with the research and tertiary teaching programs in the Australian academic community.

A prime example is the Antarctic CRC's Law, Policy and International Relations sub-program based at the University of Tasmania. The sub-program conducts research on the management of Antarctica and the southern oceans within the fields of international law, public policy and international relations. A recent review, conducted in consultation with the AAD, identified four research themes to guide the strategic development of the sub-program:

- operation of the Antarctic Treaty
- protection of the Antarctic environment
- management of Antarctic resources
- Australia's policy interests in Antarctica.

The research program for the next two years includes work on illegal for Patagonian toothfish and assessment of influence within the Antarctic Treaty system. These projects are being undertaken in close consultation with policy officers of the AAD and other government agencies. The partnership between the AAD and the Antarctic CRC on law and policy issues benefits academia by providing access to current policy issues—and the policy and legal practitioners gain from independent and rigorous academic input to their work.

The Law, Policy and International Relations program is guided by a reference group which includes representatives of the AAD and the Department of Foreign Affairs and Trade. Research outputs take the form of advice to Government, POLAR (Policy, Law and International Relations) Working Papers and contributions to the Antarctic and Southern Ocean Law and Policy Occasional Papers produced by the University of Tasmania Law School.

The Institute of Antartic and Southern Ocean Studies (IASOS) at the University of Tasmania has developed a strong teaching program that also draws on participants in the Australian Antarctic program. The institute offers an Honours Degree and Graduate Diploma in Antarctic Studies which involve multi-disciplinary course work and a thesis. The core teaching program, which is run as an intensive series of lectures and seminars runs over the first half of the academic year, covers the life sciences, physical science and Antarctic operations. The social sciences stream addresses the critical law and policy issues and includes comprehensive attention to the Antarctic Treaty system, international law and environmental protection issues. AAD policy staff have contributed to the teaching program over several years.

IASOS also provides Masters and PhD programs in a range of research areas, and supports international visiting scholars. Much of this work is conducted in close collaboration with science and/or policy staff of the AAD and has made significant contributions in a number of policy related areas. The AAD has also developed links with other Australian and overseas institutions studying Antarctic law and policy.

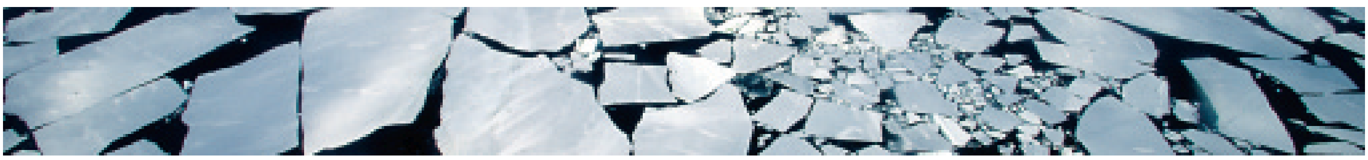
Bernadette Hince at the launch of The Antarctic Dictionary *at the Australian Antarctic Division in December* 2000. Glenn Jacobson

Antarctic Dictionary launch

The Antarctic Dictionary, a unique work on the English language spoken by 'Antarcticans', was published in December 2000. Compiled by Canberra-based scholar Ms Bernadette Hince, the book covers the English spoken by Australians, New Zealanders, US, British (including Falkland Islanders) and others throughout Antarctic and subantarctic regions.

It took Ms Hince 11 years to compile the 500-page dictionary, and involved extensive research in all the countries concerned, including visits to Antarctica and the subantarctic islands.

The Antarctic Dictionary is published by CSIRO Publishing of Melbourne, in association with the Museum of Victoria.



Fifty years ago

"**Flight to Adelie Land**—The Australian Minister for External Affairs, Mr R.G. Casey, announced on the 21st October that a 1500-mile pioneering flight from Hobart to Adelie Land on the Antarctic mainland is planned in January, 1952. Captain P.G. Taylor who will be in command will fly the same Catalina "Frigate Bird II" in which he flew to Chile some months ago. Although aircraft have been used on the Antarctic continent before, no aircraft has yet flown from a continental land base to the Antarctic.

The first lap will be from Hobart to Macquarie Island, a distance of 500 miles; and the second from Macquarie to Adelie Land, approximately 1000 miles. A Navy vessel will probably be stationed at some point on this second section. Captain Taylor proposes to consult American airmen with polar flying experience before commencing his own flight.

A successful flight would teach us a great deal about Polar navigation, said Mr. Casey, and how best to send relief if needed to Australian Antarctic bases. Later, an air survey of the Australian sector would be made.

Australia plans to establish a permanent base on the Antarctic continent within six years, but realises that she must move quickly if she wishes to hold the land—nearly three million square miles—to which she lays claim.

In the Sub-Antarctic—The Australian Antarctic Division is trying to obtain a vessel to replace H.M.A.S. Labuan, which was so severely buffetted on its Heard Island trip early this year that the Navy withdrew it from Sub-Antarctic service. It is hoped that construction of the new Antarctic ship, plans for which are being drawn up, will commence early in 1952.

Meanwhile the Division is advertising for 30 men, including scientists and carpenters, to replace in January the men at present on Heard and Macquarie Islands.

The Heard Island party is breeding sledge-dogs from huskies left by the French expedition. An experienced dog attendant with some veterinary knowledge and, if possible, skilled in sledge-driving is wanted to train the young dogs for forthcoming Antarctic work, maybe on the Antarctic continent itself.

9,000ft. high Big Ben has been sending up smoke and steam from a spot halfway up the mountain-side, where previously there was an unbroken slope of snow and ice. An attempt to investigate the new crater was barred by deep and wide crevasses.

An attempt was also made to reach Long Beach, the most Southerly part of the Island. Early in September a depot hut built on sledge runners was taken in stages by dog-teams across the snow and glaciers, and established 200 ft. above sea-level. An attempt early in October to push on to Long Beach was defeated by blizzards and poor visibility.

Three drifting icebergs have been seen at Macquarie Island this Spring. The largest, which was a quarter of a mile long and a hundred feet high, was sighted east of Lusitania Bay at the southern end of the island. Another ran aground and broke up after twelve days on the Judge and Clerk Islands, two bare rocks about eight miles north of the A.N.A.R.E. Station. The third moved north east past the Station and provided a field day for photographic enthusiasts.

This is the first time that icebergs have been sighted by A.N.A.R.E. personnel off Macquarie Island."

From *Antarctic News Bulletin No. 4, 1951*

The ANARE station at Heard Island in 1951—at its maximum extent. The dog pen and dogs can be seen at left. B Dingle