

Opportunities for Antarctic and Southern Ocean Science

A paper prepared by an independent working group for the Prime Minister's Science, Engineering and Innovation Council (PMSEIC). Its views are those of the group, not necessarily those of the Australian Government.



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Executive Summary and Recommendations

Antarctica is a vast and beautiful but hostile place, for most of the one hundred million years since Australia separated from Antarctica. The Antarctic ice sheet, and the powerful Antarctic Circumpolar Current in the Southern Ocean, have been two of the key drivers of Australian and global weather and climate. Much has been learned about Antarctica and its influence on the rest of the globe during the past century but unlocking the secrets of the biology, geology, glaciology, meteorology and oceanography of the Antarctic region remains one of the enduring frontiers of earth system science.

Australia has a proud history in Antarctic exploration and research and in the implementation of the Antarctic Treaty which has maintained Antarctica as a zone of peace and international co-operation in the wake of the International Geophysical Year (IGY) of 1957-58. The work of the Australian Antarctic Division (AAD) of the Department of the Environment and Heritage and the cross-agency and university-based Australian Antarctic science programme which it supports underpins the Government's goals for Antarctica, viz:

- To maintain the Antarctic Treaty system and enhance Australia's influence within the System.
- 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.

Most of Australia's Antarctic science is carried out by the AAD, the Bureau of Meteorology, CSIRO, Geoscience Australia and the Australian universities with collaboration and co-ordination amongst them focussed primarily in the work of the Antarctic Climate and Ecosystems Cooperative Research Centre (ACE CRC). The Antarctic science programme includes both research and long-term scientific observations. Funding support for university research is provided by Australian Antarctic Science Grants administered, and provided by the AAD. The Department of Foreign Affairs and Trade is closely involved in maintaining Australia's interests in the Antarctic Treaty system and heads the delegation to the annual Antarctic Treaty Consultative Meetings.

A recent external review by the Antarctic Science Advisory Committee (ASAC) underscored the quality and international standing of Australia's Antarctic science. The review also drew attention to the economic, social and environmental benefits that result from its contribution to the reliability of Australian weather (including space weather) and climate forecasting, to fisheries and ecosystem management, to human health and to Australia's credibility and influence in international forums dealing with marine living and non-living resources, earth observation, environmental protection and the like.

PMSEIC-IN-CONFIDENCE

The next fifteen years offer many exciting opportunities to build on the scientific achievements of Australia's work in Antarctica and the Southern Ocean over the past century. The Working Group has identified six major opportunities of particular importance to Australia.

- The International Polar Year (IPY) 2007-08, co-sponsored by the non-governmental International Council for Science (ICSU) and the intergovernmental World Meteorological Organization (WMO). With its joint planning committee co-chaired by an Australian scientist, the IPY will provide a unique opportunity to leverage international resources for a major step forward in our understanding of the Antarctic region, just as the IGY did fifty years ago.
- Establishing a new style of science for Antarctica by implementing an intercontinental air-link, to complement the existing shipping and the developing intra-continental air support system. This would increase flexibility in deploying scientists and support personnel across the vast Australian Antarctic Territory, which comprises 42% of Antarctica. It would increase their frequency of access, increase their capacity for remote area and airborne research, decrease unproductive travel time by sea and enhance our capability for collaboration with other nations' Antarctic programs.
- Enhancing our capability for weather, climate and other environmental monitoring and prediction including assessment of the likelihood and potential impacts of climate change and sea level rise. Recent developments in international co-operation in earth observations including the development of a Ten Year Implementation Plan for a Global Earth Observation System of Systems (GEOSS) provide a unique opportunity for Australia to take advantage of a host of new *in situ* and satellite-based observing techniques such as robotic 'Argo' floats and new approaches to modelling of the coupled atmosphere-ocean-ice system that are emerging from international research programmes.
- Better protecting the Antarctic environment, better understanding and managing Southern Ocean fisheries, enhancing international whale protection and safeguarding the biodiversity of the unique Antarctic ecosystems. Australia's established reputation in these areas will enable us to play a strong role in a number of international research programs including leadership of the Census of Antarctic Marine Life as part of Australia's contribution to the IPY.
- Obtaining a share of the world's next generation of optical/infrared telescopes by joining one of the international consortia working towards the development of an Extremely Large Telescope on the high plateau of Antarctica where conditions for astronomical observation are better than anywhere else on earth.
- Ensuring that growth in Antarctic tourism has minimum adverse impact on the pristine Antarctic environment by undertaking research into the management of potential environmental impacts.

These and the many other opportunities opened up through recent developments in Antarctic science, technology, logistics, management and international co-operation offer potential benefits to Australia that far exceed their cost and even greatly exceed the benefits achieved in the past. The Working Group recognises, however, that resources are limited and that it will not be possible to pursue all of the promising opportunities. It is necessary, therefore, to establish a clear vision for the future of Australia's Antarctic and Southern Ocean science and identify priority actions that will enable the vision to be achieved.

Our achievement in the past has been based on the excellence of our science in the areas that matter most for Australia and where we have historically taken a lead. Our vision for the future is that **Australia will lead the world in key areas of Antarctic and Southern Ocean science over the next fifteen years**; and that, through our leadership in key areas of ice, ocean, atmosphere and biodiversity research, we will enable Australia to benefit, ever more greatly from:

- Better forecasting of weather and climate;
- Improved understanding and conservation of Antarctic and Southern Ocean biodiversity; and
- Enhanced economic rewards from fisheries, biotechnology and tourism.

Australia's Antarctic science is well placed to enable us to achieve this vision. Priority should be given to:

- The International Polar Year.
- An air-link to Antarctica.
- Earth observation.
- Institutional arrangements for research.

We therefore offer the following four recommendations for the development of Australian Antarctic and Southern Ocean science over the next fifteen years.

Recommendation 1: Undertake a period of enhanced scientific activity for the International Polar Year to advance our research by leveraging off the activities of the international partners in the programme.

Recommendation 2: Implement an air transport system from Australia to Antarctica to complement the existing shipping program and the developing intra-continental air transport system in Antarctica.

Recommendation 3: Play a leadership role in developing and implementing a Southern Ocean observing system and the next generation of *in situ* data-gathering instrumentation for use in Antarctica and remote locations.

Recommendation 4: Secure stable long-term institutional arrangements for collaborative Antarctic research across all fields of biology, geology, glaciology, meteorology and oceanography.



John Wilson © AAD



Mike Whittle © AAD



Jane Goddard © AAD



Wayne Papps © AAD

1 INTRODUCTION

"Great God! This is an awful place"

- attributed to Captain Robert Falcon Scott, on reaching the South Pole, January 18th 1912.

Dark for six months of the year and wracked by gales and blizzards, it presents a huge challenge to those who live and work there. Yet, Antarctica is an exciting, fascinating and important place. We now know that it is a key driver of Australian and global weather and climate and controller of the biological productivity of the Southern Ocean.

The Super-continent Gondwana

For a long period until about 100 million years ago Australia was part of the large southern super-continent of Gondwana that also included Antarctica, Africa, South America and India. Driven by convection in the Earth's deep interior, the super-continent broke up and Australia separated from Antarctica and slowly drifted northwards. It continues to do so, at an average 6-8 centimetres every year. The two continents had a common history for a prolonged period of time and both are marked by the process that rifted them apart. Where the crust was stretched, it also subsided and large sedimentary deposits, some of which are hydrocarbon bearing, formed on the margins of both continents. The movement of Australia and the other southern continents away from Antarctica led to significant rearrangement of the global ocean circulation, development of the Antarctic Circumpolar Current, a cooling of the southern continent, and the first growth of the ice sheet. The history of this early climate evolution, as well as of more recent glacial cycles, is contained in the sediments flanking the Antarctic continent. Australian geoscientists have played a key role in unlocking the secrets of the distant and more recent pasts of the two continents and in providing new insights into climate change and non-living resources.

For almost 60 years, Australia has conducted a programme of scientific research and observation on the icy continent, in the waters around it and on the sub-Antarctic islands. The programme is strategically focused and maintains Australia's position as a significant and respected member of the Antarctic family of nations. Our scientific effort focuses on many of the big environmental issues facing Australia and the world in the 21st century.

Key Facts about Antarctica

Antarctica is almost twice the size of Australia. It is the coldest, highest, driest continent on Earth. Antarctica contains the largest store of freshwater on earth, sufficient to raise sea level by over 60 metres.

Australia's Antarctic Territory (AAT) covers nearly 42% of the Antarctic continent, or 5,896 500 km². Exposed rock constitutes less than 1% of the AAT. The AAT is predominantly an ice plateau, with some parts over 4,000 metres above sea level, and contains the world's largest glacier (the Lambert Glacier). The world's lowest recorded temperature (-89.6 °C) was recorded at Vostok Station in the AAT.

Australia's only active volcanoes are on the sub-Antarctic Heard Island and McDonald Island.

The Antarctic and Southern Ocean is home to unique flora and fauna, from the largest mammal, the blue whale (100 tonnes) to its tiny prey, the krill (less than 1 gram).

Maintaining the Antarctic Treaty System is a key feature of Australian Government goals for Antarctica (see below). The Antarctic Science Programme is the foundation for the achievement of those goals.

Australian Government Goals for Antarctica

- To maintain the Antarctic Treaty System and enhance Australia's influence within the System.
- 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 Research Priorities for Antarctica (2004-09)

- Ice, ocean, atmosphere and climate.
- Southern Ocean ecosystems.
- Adaptation to environmental change.
- Impacts of human activity in Antarctica.

1.1 Scientific research and observations

The Australian Antarctic Science Programme involves both research and long-term scientific observations.

Antarctic research is broadly based, thematic and multidisciplinary by its nature, similar to the aspirations for research in the *National Research Priorities*. Antarctic research directly contributes to these priorities.

Early Exploration and Mapping – A Proud History

Australia's involvement in Antarctic exploration and science extends back over 100 years. In 1899 a Tasmanian physicist, Louis Bernacchi, was the first Australian to winter in Antarctica to conduct science. In 1904 Douglas Mawson joined Shackleton's expedition to find the magnetic South Pole, and he returned in 1911-14 with his own expedition dedicated to Antarctic science to the region immediately south of Australia. This expedition, and his work in further expeditions (1929-31), set the foundation for the Australian claim to the Antarctic territory, putting Australia on the Antarctic map in a geographical sense and with respect to the pursuit of high quality science.

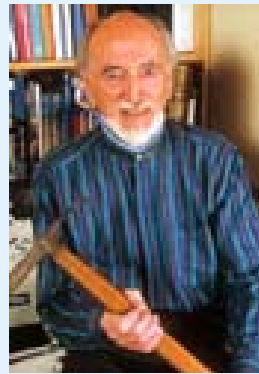
Mawson's legacy was the post-war establishment of two scientific stations on the subantarctic islands, followed in 1954 by the first permanent station on the continent itself, under the leadership of Dr Philip Law. Mawson station, which celebrated its 50th anniversary this year, is the oldest continuously occupied station south of the Antarctic Circle.



Louis Bernacchi



Sir Douglas Mawson



Dr Philip Law

© AAD

A large part of the research programme is conducted by scientists based in Australian universities, with over 50 projects supported by the Australian Antarctic Science Grants scheme through a peer review evaluation process. A very significant component is the scientific work of staff employed by the Australian Antarctic Division (AAD) of the Department of the Environment and Heritage. The Antarctic Climate & Ecosystems Cooperative Research Centre (ACE CRC) provides a focus for research carried out across a number of agencies. Other organisations engaged in Antarctic research and observations include the Bureau of Meteorology, CSIRO, and Geoscience Australia. Scientists employed by various state agencies and overseas universities and institutions also collaborate in projects as part of Australia's Antarctic science effort.

Observational data collected from Antarctica and the Southern Ocean is crucial to weather forecasts across the globe. Observations from the three Antarctic bases and Macquarie Island are essential input to the complex computer models used in weather forecasting. Regular weather forecasts for the Antarctic underpin the operations and safety of Australian activities in the region. The collection of observational data is also crucial to monitoring environmental issues. Examples include changes in the Antarctic environment over time, and data on the size of the ozone hole and the status of the stratosphere above the Antarctic.

1.2 Benefits from Antarctic science

Australia's investment in Antarctic science has brought economic, social, environmental and international relations benefits to Australia over the past six decades. Benefits have included more accurate weather forecasting, improved fisheries management, environmental protection, the development of novel techniques for remediating contaminated frozen ground, better understanding of human health in extreme environments, assembly of unique long-term data sets, and enhanced Australian influence among Antarctic nations.

Australian Antarctic science has an excellent record of achievement as judged by qualitative and quantitative indicators (see below).

Antarctic Science Advisory Committee (ASAC) Report

In 2002-03 ASAC evaluated Australia's Antarctic Science Programme by engaging an independent team of internationally recognised scientists from Australia and overseas.

The team were asked to evaluate the quality of the science, its relevance to the national Antarctic Programme, the performance of research projects, and finally to provide advice on new research directions.

The team stated that "Australia is well served by its Antarctic science programme" and that it represents "a remarkable contribution by Australia to world science", and recommended that "the strengths in the individual components of the program be maintained".

Research and observation of Antarctic weather and climate is economically important as it helps predict rainfall patterns over Australia and future changes in sea level. Research on the ecology of the Southern Ocean is essential to the management of the natural resources of the Southern Ocean. This focus responds directly to the *National Research Priority "An Environmentally Sustainable Australia"* through the goals on *Responding to Climate Change and Variability* and *Sustainable Use of Australia's Biodiversity*. It also has the potential to contribute to the goal of *Transforming Existing Industries*.

As Australia is a signatory to the Antarctic Treaty, the quality of Australia's Antarctic and Southern ocean science is a tangible way to protect Australia's interest and is not without relevance to a second National Research Priority *Safeguarding Australia*.

1.3 International influence

Following its influential role in the development of the Antarctic Treaty, Australia has continued to exert considerable influence in many forums. Our ability to influence debate and drive policy agendas has been based in large part on the fact that we have maintained a high quality, multi-disciplinary, research programme throughout the 43 year history of the Antarctic Treaty system.

Our research has underpinned initiatives which we have taken forward in both scientific and policy forums. The standing of Australian Antarctic science has enhanced Australia's influence in the Antarctic Treaty, the Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR), and other forums far beyond that expected for a nation of 20 million people.

The Antarctic Treaty System and International Cooperation

In the late 1950s, world politics was dominated by the Cold War. In Antarctica, the race for tactical advantage was demonstrated through the strategic establishment of stations by the super-powers.

It was in this context that the International Geophysical Year (IGY) was undertaken in 1957-58. In stark contrast to international relations elsewhere on the globe, the IGY generated a spirit of international cooperation, with IGY parties cooperating in Antarctic research. It also demonstrated that the super-powers could work co-operatively, even during the height of Cold War tensions, and the pursuit of scientific investigation became the *raison d'etre* for the Antarctic Treaty.

The Treaty System has grown into a sophisticated international legal regime that embraces instruments regulating, among other things, the harvesting of fish and krill, through the Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR). It has also provided comprehensive protection of the Antarctic environment, through the adoption in 1991 of the Environmental Annex to the Antarctic Treaty.

The Antarctic Treaty has, for the past four decades, maintained a zone of peace and harmony to Australia's south. The demilitarisation of Antarctica has ensured that Australia has had no requirement to maintain a military presence in the region, resulting in a very considerable cost saving to the nation's defence budget. Maintaining the Antarctic Treaty, and encouragement of nations that are not yet parties to the Treaty to become so, are clearly in the national interest. Further details are provided in Appendix 4.

1.4 Ice

Ice dominates the Antarctic region, both on the land and on the ocean.

Ice sheet

A vast ice sheet, nearly 5 km thick at its maximum covers the continent. This has built up from successive accumulation of snow, and the ice at the bottom can be up to a million years old. The ice slowly moves downhill toward the coast where it converges into faster moving glacier streams and floating ice shelves which fringe Antarctica.

Australian scientists have been investigating the balance between snowfall and ice melt. One of the larger and more dynamic parts of the ice sheet, the Totten Glacier near Casey station, has shown a 10 metre decrease in ice thickness over the last 16 years - a decrease similar to the alarming changes that are occurring in some other parts of Antarctica. If the thickness of the ice sheet continues to decrease, ocean levels will rise. This will add to the increases in sea level that are occurring as a direct result of ocean warming.



The very old ice in the ice sheet preserves a priceless record of past environments, including atmospheric constituents and climate. Australia has recovered and analysed a 1,200 metre deep ice core from the ice sheet inland of Casey station. The total record in this core covers more than 80,000 years, allowing scientists to assess Antarctic environmental change in relation to global climate fluctuations. Air bubbles trapped in ice provide a record of past atmospheric composition. Analysis of the air in these bubbles shows that the level of carbon dioxide in the atmosphere today is about 30% higher than its level before the industrial revolution and indeed higher than at any time in the last 420,000 years.

Ice shelves

Most of the ice that drains from the interior of Antarctica does so via massive glacier streams (like the Totten Glacier) that often reach the ocean as floating tongues or shelves.

Australian research shows that where the glacier contacts sea water, up to 50% of the total ice loss occurs through melting beneath the floating ice. Other loss occurs from iceberg calving, often as massive bergs that can be tracked by satellite.

The shelves and floating tongues are most vulnerable to change as evidenced by the spectacular collapses of the Larsen B ice shelf on the Antarctic Peninsula. Here, in 2002, a 3,250 km² area (one and half times the size of the Australian Capital Territory) of ice over 200 m thick disintegrated into small icebergs in only 35 days.

The largest ice shelf in the Australian Antarctica Territory, the Amery Ice Shelf between Mawson and Davis stations, is the subject of an intensive study to understand the processes of interaction between the ocean and the ice that could lead to such disintegration, and the processes by which icebergs are shed. This programme includes drilling several hundreds of metres through the ice to access the underlying ocean to unravel the processes involved in melting of the Antarctic ice shelves.



Wayne Papps © AAD

Sea ice

Each winter the surface ocean around Antarctica freezes, forming a layer of sea ice averaging 1 m in thickness covering an area of 20 million square kilometres (nearly three times the area of Australia). In summer most of this melts leaving only about 3.5 million km². This sea ice cover modifies heat exchange between ocean and atmosphere and has a major influence on ocean circulation and on weather and climate in Australia. The sea ice fashions Antarctic habitats and is of fundamental importance to marine ecosystems and biological productivity. Changes to sea ice extent would affect sustainable harvesting of the Southern Ocean.

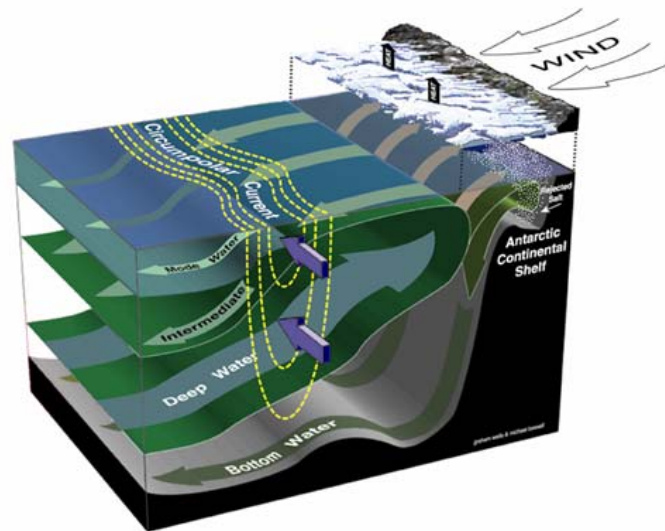
Analysis of air bubbles trapped in ice cores, and from other proxy records, reveals evidence that the maximum extent of sea ice may have decreased by up to 25% during the 1950s and 1960s. In the 30 years since the 1970s, when satellite observations first became available, there is little evidence of further reduction.

There are few past data on ice thickness, and so Australian research is now directly mapping sea ice thickness and determining patterns of sea ice motion around Antarctica to estimate whether seasonal sea ice is changing in thickness or distribution, possibly related to changes in global climate.

1.5 Oceans

The Southern Ocean surrounding Antarctica is a key component of the global climate system and connects the world's three major ocean basins – the Pacific, Atlantic, and Indian. Its circumpolar nature is the main reason why the impact of climate change in the Southern Hemisphere (and hence in Australia) is likely to be different from that in the Northern Hemisphere.

Ocean Thermohaline Circulation



A schematic illustration of the major ocean circulation pathways in the Southern Ocean. The Antarctic Circumpolar Current (ACC) flows in an eastward direction, transporting water between the Indian, Pacific, and Atlantic Oceans. Over the Antarctic Continental Shelf, ice formation creates highly salty dense water that eventually sinks to the abyssal ocean. This so-called "Bottom Water" is part of the global ocean overturning circulation; it is rich in nutrients and oxygen and affects global climate. About 75% of the global ocean's deep water comes from the Southern Ocean, much of it from the Mertz Glacier Polynya in the Australian Antarctic Territory.

Circling Antarctica is a massive eastward flow of seawater known as the Antarctic Circumpolar Current (ACC). This current carries about 140 million cubic metres of water per second from west to east along a 20,000 km long path around Antarctica. This flow is equivalent to about 150 times the combined flow of all the world's rivers, or 25% of the volume of Sydney Harbour every second.

Understanding the role of the ACC in the transport of cold water and its links with the El Niño phenomenon of the equatorial Pacific Ocean is critical to our understanding of what influences Australia's weather and climate.

The density-driven global “overturning” circulation transports heat, carbon dioxide, and oxygen around the globe and plays a major role in the Earth’s climate system. Australian scientists have demonstrated that the Southern Ocean is a key link in this global “conveyor belt” by connecting the upper and lower parts of the overturning circulation, as illustrated in the diagram above. This work is helping to shape international thinking about Antarctica’s role as a driver of ocean and climate processes. We have observed a slowing of the circulating “Antarctic Bottom Water”, with models indicating a possible eventual shutdown of its formation in response to greenhouse warming. Such a collapse would have dramatic impacts on global climate and life in the oceans.

Our researchers, in collaboration with overseas colleagues, have been able to demonstrate that the Southern Ocean, through its phytoplankton, absorbs carbon dioxide like a huge forest. The Southern Ocean’s ability to store carbon dioxide (more than 40% of the total human-generated carbon dioxide stored by the world’s oceans) has reduced the rate of global warming. Clearly, understanding the capacity of the Southern Ocean to absorb more (or less) human-made carbon dioxide as global climate continues to change is crucial to our understanding of climate change and managing greenhouse gas increases.

1.6 Atmosphere, weather and climate

Australian meteorologists have in recent years led the international efforts to improve Antarctic weather forecasting, in particular through the production of the International Antarctic Weather Forecasting Handbook, recently adopted as ‘the standard’ by the international Antarctic community.

Meteorological observations available from Antarctica since the 1950s have made a major contribution to the quality of day-to-day weather forecasting for Australia. These observations are also an essential part of the operation of the World Meteorological Organization (WMO) World Weather Watch which supports weather prediction for the entire globe.

An important local meteorological phenomenon in Antarctica is the so-called katabatic wind. The layer of Antarctic air nearest to the ice is cooled, hence becomes denser and flows down slope under the influence of gravity to produce persistent and strong katabatic winds. Since the ice sheet is dome-shaped, the surface slope increases near the edge and katabatic wind speed is greatest near the coast. These winds can reach speeds well in excess of 90 km per hour and can endanger shipping and scientific activities.

Complex computer models of the atmosphere and meteorological observations have been vital in improving our understanding of both large-scale processes and regional phenomena such as the katabatic winds. This knowledge has led to improved accuracy and detail of weather forecasts for Antarctica and the Southern Hemisphere as a whole.

Long-term observations in Antarctica and the Southern Ocean have provided the basis for research on how the region influences the global climate system including the climate of Australia. In recent decades, the structure of the stratosphere above the Antarctic has been affected by ozone-depleting substances and this, in turn, has impacted on the larger atmospheric circulation of the Southern Hemisphere. There is evidence that these changes have offset some of the expected effects of the enhanced greenhouse effect. It also appears that variations in the circulation of air in this part of the atmosphere are associated with inter-annual and inter-decadal fluctuations in the climate of Southern Australia. There is evidence that the frequency of low pressure systems in the latitude band 40°-60°S has decreased, and will continue to decrease, in response to increasing greenhouse gases, mainly as a result of a projected poleward shift in the Southern Hemisphere jet stream. This significant adjustment in the extratropics could have profound, but as yet uncertain, impacts on Australian climate.

Australian scientists have made significant contributions to the development of reliable global models of the coupled ocean-atmosphere system, with a particular emphasis on their application to the Southern Hemisphere. These models are used to elucidate the dynamics of past climate events, to project future human-induced climate change, and to understand and predict natural climate variability and extremes.

1.7 Ecosystems

Biodiversity

Antarctica's biodiversity is characterised by its ability to function at extremely low temperatures, both on land and in the ocean. The structure of terrestrial ecosystems is quite well known but much of the marine environment is unknown. The biotechnological potential of Antarctic biota is high with many species producing compounds of value to humankind, such as polyunsaturated fatty acids, antifreezes, antioxidants, antibiotics, biocides and low temperature enzymes.



Diane Calder © AAD

Marine micro-organisms (phytoplankton, protozoa and bacteria) account for over 95% of the biomass of the Southern Ocean. As well as constituting the base of the food web on which all other marine organisms depend, they play a major role in the exchange of carbon dioxide between the atmosphere and ocean and in the production of the oxygen we breathe. In addition they produce chemicals which, when ventilated to the atmosphere, form aerosol particles which promote cloud formation. Clouds play an important role in controlling how much of the Sun's radiation reaches the surface of the Earth and how much is reflected back into space. Marine micro-organisms are influenced by climate change but also play a role in its detailed behaviour.

Because Antarctic plants and animals live under extreme conditions, often at the limit of biological existence, they are being used as a sensitive detector of environmental change.

A new programme, *Adaptation to Environmental Change*, is using DNA-based technology and other molecular techniques to obtain a better understanding of how animals and plants survive under extreme conditions and how vulnerable they might be to changes in climate.



Wayne Papps © AAD

Biodiversity is not static. Dramatic changes are occurring at the present time. The retreat of glaciers and the invasion of organisms that are not native to Antarctica are modifying ecosystems. Krill abundance in the Southern Ocean has decreased since the 1970s. This decline has had a negative effect on

stocks of baleen whales, penguins, seals and other Antarctic wildlife that depend upon krill for survival. Our future management of Antarctica and the Southern Ocean depends upon how quickly we understand the ecosystem and how quickly we can introduce adaptive management strategies to protect it.



Clive McMahon © AAD

Sustainable management of the Southern Ocean

Whales, seals, penguins, fish, squid and krill have all been commercially harvested in the Antarctic region over the past 200 years, usually with disastrous effects

on individual species and whole ecosystems. While fisheries in the Antarctic region today are focused on Patagonian toothfish, mackerel, icefish and krill, there is potential for new fisheries to emerge and for these existing fisheries to expand.

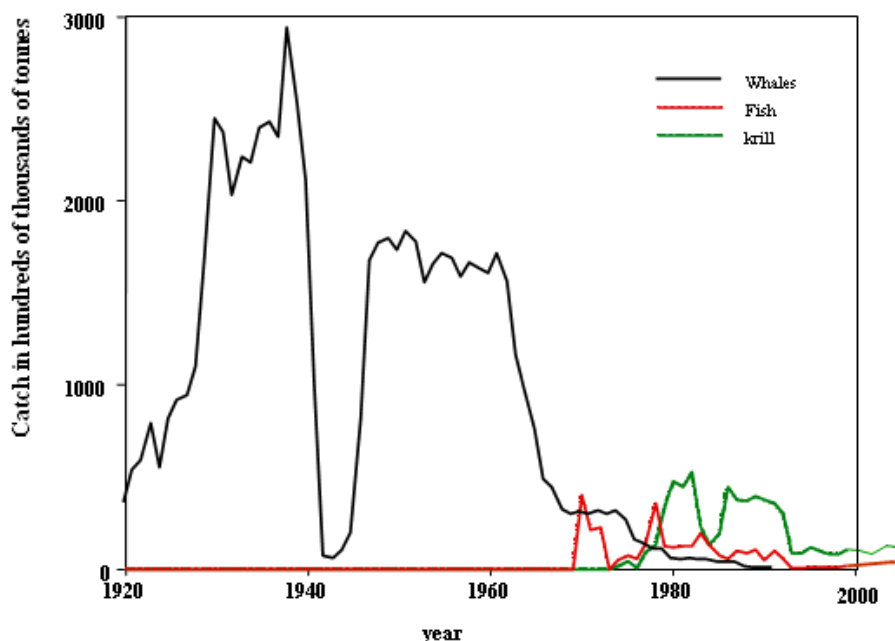
Australian research is used widely in the

development of management strategies to protect the Southern Ocean from the over-harvesting of marine living resources. CCAMLR takes an "ecosystem" approach to the management of fisheries in the Southern Ocean by considering the needs of both the harvested species and species that depend on them. Our scientific work underpins our ability to achieve sustainable harvesting without adversely affecting the populations of animals that depend on these resources.

Australia's strong influence in CCAMLR is based on our acknowledged scientific achievements. Australia's research has been used to set precautionary catch limits on most species of fish and krill in Australian exclusive economic zones around Antarctica and our sub-Antarctic islands. Our work on reducing the accidental killing of albatrosses is internationally renowned. Australian fishery models and software have been widely adopted by CCAMLR and used to manage other fisheries in the Southern Ocean. The ACE CRC will develop new ecosystem models for Antarctica and the Southern Ocean that will be used by CCAMLR to further improve management of Antarctic living resources.

With the krill fishery in the Southern Ocean poised to expand rapidly over the coming decade, Australia has positioned itself strongly to ensure the fishing industry grows in a sustainable manner.

Antarctic fisheries



1.8 Protecting the Antarctic Environment

Australia led the development of the Protocol on Environmental Protection to the Antarctic Treaty (Madrid Protocol) which entered into force in 1998. All parties to the Madrid Protocol are committed to the comprehensive protection of the Antarctic environment.

In the fulfilment of Australia's commitment to the Madrid Protocol, we have established the first Antarctic Contaminated Sites Register to record details of contamination status, environmental impacts and management of contaminated sites in the Australian Antarctic Territory (AAT). We have commenced a long-term programme cleaning up contaminated sites and have set new standards by complying with the Madrid Protocol requirement that clean-up is achieved without creating additional adverse impacts.

Australia has taken an active role in understanding and protecting the environment. We have undertaken pioneering research on the impacts of human activities in Antarctica that has resulted in better environmental practices within Australia's Antarctic Programme, other national Antarctic programmes and by Antarctic tourist operators. For example research on the effects of disturbance to wildlife has led to improved guidelines for visitors, and to more stringent controls on the use of aircraft in the vicinity of wildlife. Research on the risk to Antarctic wildlife of introduced disease led to the development of a response plan for the discovery of suspected disease in birds and seals in the AAT – a first for any nation. Australia is a world leader in Antarctic environmental protection. To maintain this position we must continue this research, working closely with the international community.

1.9 Polar Medicine

Each Antarctic station carries only one doctor - who must therefore have the necessary skills to act as general practitioner, emergency physician, surgeon, anaesthetist, nurse, radiographer, laboratory technician, pharmacist and dentist. In addition to their clinical duties, many Antarctic doctors carry out research in fields such as nutrition, immunology, thermal and exercise physiology, microbiology and psychology.

The research focuses on the vulnerability of totally isolated groups in Antarctica whose ability to resist infections may be influenced by stresses induced by the extreme environment. The focus is on immunological changes experienced by expeditioners, changes to their behaviour as the period of isolation progresses, and their physiological adaptation to cold.

The unique practice of remote and extreme medicine is also used as a test bed for other remote and extreme environments including remote regions of Australia, and even space. Productive and successful scientific research in collaboration with the United States' National Aeronautics and Space Administration (NASA), who are interested in preparing astronauts for long periods of isolation in space, commenced in 1993 and furthers Australia's influence within the Antarctic community.

Antarctic medicine also finds applicability in Australia's industrial practices that involve the use of freezer facilities and cold rooms.



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© Eric Woehler, courtesy AAD



Longline vessels in the Southern Ocean can attract vast numbers of seabirds. This vessel, which is surrounded by several hundred black-browed albatrosses, was fishing on the Patagonian toothfish grounds at the Burdwood Bank, south of the Falkland Islands

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2 NEW AND EMERGING ISSUES & OPPORTUNITIES

2.1 International Polar Year

The International Council for Science (ICSU) and the World Meteorological Organization (WMO) have designated 2007-08 as the International Polar Year (IPY), which will follow fifty years after the International Geophysical Year (IGY) that gave birth to the Antarctic Treaty.

The IPY will provide a rare opportunity for us to influence and benefit from a major international collaboration on the physics, chemistry, biology and ecology of Antarctica and the Southern Ocean. The activities of the IPY will include recording the biodiversity and species distribution in, and ecological structure of, the Southern Ocean, as well as the physical properties of waters surrounding Antarctica. The IPY will also provide a framework for international collaboration to improve our capability to predict weather and climate variability in Antarctica and across the Southern Hemisphere. Geophysical measurements will enhance understanding of the past evolution of the climate and geology of Antarctica.

The IPY will maximise the international scientific effort through highly coordinated collaborative research projects and lift our understanding of the Antarctic to a new level that will underpin our research activities for the next decade.

The IPY provides a unique opportunity for Australia to take a lead role in raising awareness, both nationally and internationally, of the effect that the Antarctic and the Southern Ocean has on the Earth's climate and ultimately environments, ecosystems and human society.

Australian Antarctic Arts Fellows

Opportunities: An improved understanding of Antarctica's role in Australian and global weather and climate, and a better understanding of the biodiversity, ecology, and circulation of the Southern Ocean.

2.2 A new style of science for Antarctica

Shipping has provided Australia's key link and lifeline to Antarctica since the heroic era of exploration. In order to undertake scientific field research, however, scientists must cross thousands of kilometres of the world's stormiest seas and penetrate through Antarctica's sea ice barrier. With most round trips taking about 2 weeks, and only two or three visits to each station annually, we need better access to Antarctica.



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An intercontinental air-link between Australia and Antarctica is the key to this. An air-link, coupled to the developing intra-continental air support system, would increase flexibility and responsiveness in deploying scientists and support personnel, increase the frequency of their access, increase the capacity to support remote area and airborne research, decrease unproductive travel times, and increase our ability to collaborate with other national Antarctic programmes. Collaboration and cooperation with other national Antarctic programmes would strengthen Australia's ability to generate ideas and undertake research. The shorter turnaround times would encourage greater involvement of senior scientists, and so help ensure that Australia remains innovative and influential. It would also enable the programme to expand into new areas including geophysical mapping, atmospheric sampling, and other areas of emerging Antarctic science. Ship time available for research during the multi-purpose voyages to and from Antarctica is increasingly limiting our ability to expand important marine science in the Southern Ocean. Use of aircraft for transporting people, however, will free up research ships for more productive marine science research.

Opportunities: Increase effectiveness and efficiency of the Australian Antarctic Programme, build collaboration internationally, make Australia the preferred destination for international Antarctic scientists and Antarctic Agencies, and enable Australia to investigate the full extent of its Antarctic Territory.

2.3 Enhanced Observation and Prediction

There is general agreement that human-induced climate change is one of the most serious global environmental issues facing the world today.

Australian scientists have shown that the record high temperatures which exacerbated the impact of the 2002 Australian drought may have been due to greenhouse warming. These higher temperatures reflect a continued warming of Australia since the mid 20th century and the most likely explanation for this general warming is anthropogenic climate change. It is therefore vitally important for Australia to understand both natural climate variability and the potential for human-induced change in our region. Incorporating climate knowledge in planning can enable adaptive strategies to be implemented.



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Prediction of ocean conditions can minimise operating costs for shipping, fishing, and tourism. Technical and scientific advances are beginning to deliver accurate data on the physical aspects of the ocean environment (temperature, salinity, current direction and speed) and their relations to climate. International plans for deploying 1,000 remotely-operating recording floats (Argo floats, shown in the picture) in the Southern Ocean will revolutionise our ability to monitor and predict the ocean's properties, as will advances in remote sensing from satellites, remotely-operated under-ice vehicles, scientific moorings, and new methods for assimilating disparate observations. Understanding how marine ecosystems respond to physical change presents considerable challenges to which we must rise if we are to anticipate and adapt to the responses of Antarctic and Southern Ocean ecosystems to a changing world.

Opportunity: Provide more accurate observation, assessment and prediction of the Southern Ocean and Australian environment and Antarctic marine ecosystems through participation in revolutionary observing systems.

Ice sheets and shelves

Significant uncertainty surrounds the stability of parts of the Antarctic continental ice mass.



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Floating ice shelves are sensitive to changes in air and water temperature and the rate at which they calve off icebergs might be an indication of environmental change. The amount of fresh water in some ice sheets is vast - the West Antarctic ice sheet alone, for example, contains enough water to raise the world's sea level by about 5 metres. Sea level rises of even a few tens of centimetres would cause substantial floods, with damage to property and a threat to life in many low lying islands and coastal regions around the world.

The Intergovernmental Panel on Climate Change (IPCC) has projected that the sea level will rise between 9 and 88 centimetres from a combination of ocean warming (and resultant thermal expansion) and the melting of land based ice by the year 2100. This would increase significantly the vulnerability of coastal areas to extreme events such as cyclone storm surge.

There is concern about the stability of the West Antarctic and other ice sheets and satellite observations are now revealing an accelerated rate of flow of some glaciers. Improved understanding of the dynamics and stability of the Antarctic ice sheet is critical to resolving whether recent changes are natural variations, or whether they signal significant changes which may bring long-term impacts on sea level and coastal ecosystems.

(Below: A Jorg Schmeisser etching of Antarctica)



Opportunity: Predict the likelihood and extent of sea-level rise caused by the melting of Antarctic ice sheets.

Changing oceans

The Southern Ocean provides a critical link to the deep overturning circulation that controls movement of water throughout the world's oceans, significantly regulating global climate as well as the rate of absorption of carbon dioxide from the atmosphere. The Southern Ocean absorbs over one third of the human-produced carbon dioxide that is absorbed by the world's oceans, although climate change will almost certainly alter this absorption rate, though by how much is not yet clear. The stability of the ocean's overturning circulation is one of the key uncertainties in future climate prediction. A primary goal of future Antarctic and Southern Ocean research is to assess the probability of a collapse of the Southern Ocean overturning circulation and to determine the impact of such a collapse on sea level rise, carbon storage, marine ecosystems and our climate.

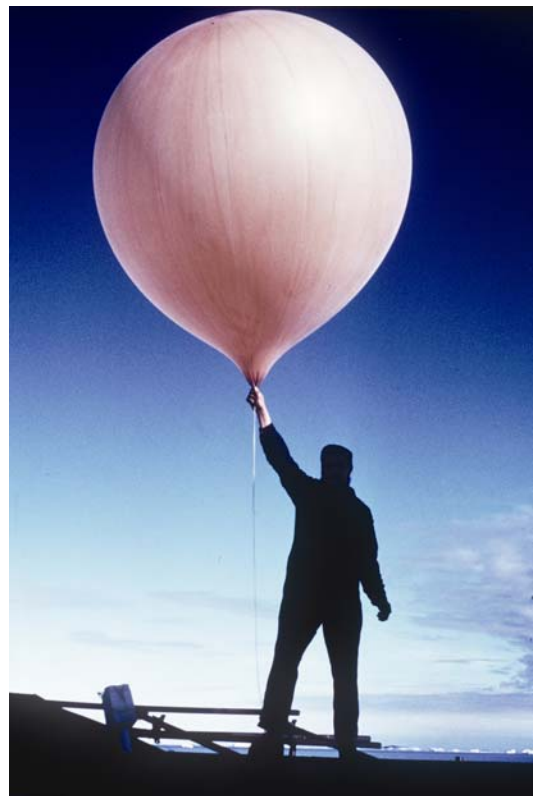
Australia's proximity to the region positions our scientists as leaders in the measurement and understanding of Southern Ocean circulation and carbon storage. New ocean observing systems and improved ocean climate models will also help Australian scientists quantify changes in the Southern Ocean.

Opportunity: Better understand the role of the Southern Ocean in climate change.

Weather and climate

An enormous range of new scientific and technological opportunities for improving understanding and prediction of Antarctic and Australian weather and climate is emerging through international research programmes and initiatives such as the proposed the Global Earth Observation System of Systems (GEOSS).

These have the potential to enable us to document and understand the unique character of Antarctica and the Southern Ocean and monitor its changing weather and climate. Complementary programmes of observations and modelling will allow us to improve our ability to predict and track severe storms in Antarctica and over the Southern Ocean. This will improve our overall weather prediction capabilities for Australia and the world.



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Long-term measurements help us to detect and understand climate change associated with both ozone-depletion and the enhanced greenhouse effect. We need to know how the Southern Hemisphere will respond in the coming decades as the effects of ozone depletion declines while global temperature continues to rise. We must clarify the impacts of the variations in the large-scale atmospheric circulation around Antarctica on Australian climate and monitor the expected recovery of the ozone layer. Because of the large seasonal variations in the extent of sea ice around Antarctica, special attention should be given to understanding the role of this annual cycle of sea ice formation and melting in the climate of the Southern Hemisphere.

Opportunity: Improve forecasting of weather and climate and understand the effects and likely impact of climate change.

2.4 Biodiversity

Knowledge of Antarctica's marine biodiversity is patchy. The biodiversity of marine mammals and birds is fairly well known, as is the bottom fauna¹ of a few relatively small parts of the continental shelf and near-shore regions. At the other extreme, almost nothing is known about the pelagic fauna² of the mid-waters and deep-oceans or the organisms that live on the deep sea floor. Similarly, the micro-organism diversity is poorly documented, but new molecular biological techniques are indicating that there are many thousands of unknown and undescribed species.

Conservation

Australia has taken the initiative to lead an international Census of Antarctic Marine Life (CAML), an ambitious 5-year project that will focus the attention of the public on the ice-bound oceans of Antarctica during the International Polar Year in 2007-08 and beyond. Its bold objective is to study the evolution of life in Antarctic waters to determine how this has influenced the diversity of the present plants and animals, and to use these observations to predict how Antarctic organisms might respond to future change in their environment. The Census provides us with an opportunity to understand the biodiversity of our extended continental shelf, recently the subject of international submission, and to further demonstrate our international leadership in marine science.

Knowledge of evolutionary adaptations to a cold environment provides us with opportunities for the isolation and commercialisation of biochemicals and gene sequences of use to humankind.

¹ Bottom fauna – animals that feed on the bottom of a body of water.

² Pelagic fauna - animals or plants living at or near the surface of the ocean, far from land.

Our scientists are actively examining the effects of ocean variation on the biology of Adélie penguins, near Mawson station, through the CCAMLR Ecosystem Monitoring Programme – an international programme using identical observational methodology in a number of Antarctic locations. Other marine predators, such as seals and whales are also being tracked by satellite across the ocean as they roam in search of their food to assess how these searches are related to oceanic features, such as water temperature, gyres and plankton blooms. Understanding these relationships is a critical component of understanding how Antarctic marine ecosystems will respond to a changing environment.

Opportunity: Protect the environment and our resources by better understanding Antarctic and Southern Ocean biodiversity.

Ecologically Sustainable Fisheries

The Southern Ocean contains the largest unexploited fishery resources known, primarily in the form of Antarctic krill. Krill is becoming an increasingly important source of protein for manufacturing feed for the booming global aquaculture industry, where demand for feed is now exceeding supply. Fisheries for toothfish are internationally important but also the focus of illegal, unregulated and unreported (IUU) fishing that represents a significant threat to populations of these fish.

Australian science provides major contributions to assessments of the status of harvested krill and fish populations in the Southern Ocean and, by doing so, influences the formulation of management strategies either by CCAMLR or national authorities such as the Australian Fisheries Management Authority.

Fisheries management today requires an ecosystem approach to ensuring sustainability. This means that fisheries must be regulated to be sustainable in terms of both the harvested species and other species that might suffer indirect impacts, either by incidental capture or because of food-chain effects of removing large amounts of one or more species. Here too, our scientists are major contributors to achieving ecologically sustainable fisheries in the Southern Ocean.

A recent study conducted in the Heard Island and McDonald Island Marine Reserve derived a food-web model of how penguins, seals, albatrosses and petrels interact with their prey. Such information is central to establishing ecologically safe harvesting levels of fish and other commercial species.

So too is our research into the mitigation of non-target by-catch in the long-line fishing industry. The work, which has been internationally acclaimed, is continuing to persuade national fishing fleets in the Southern Ocean to adopt new environmentally friendly techniques to minimise unnecessary environmental damage and must continue apace if our work is to save species currently under threat.

Opportunity: Better manage the exploitation of Southern Ocean Fisheries through knowledge of the ecosystem and by mitigating adverse effects of harvesting.

Whales

The over-exploitation of the Southern Ocean whales has left many species at critically low numbers. For example, Antarctic blue whales are still less than 1% of pre-exploitation numbers. Since widespread commercial whaling ended 25 years ago, Australia has been a lead voice in the International Whaling Commission (IWC) for the conservation of whale stocks through a global ban on commercial whaling. Australia's policy position is now increasingly underpinned by high quality science which evaluates, among other things, the role of whales in the ecosystem, the abundance and trends of whale stocks, the movements and distribution of Southern Ocean whales, as well as assessment of the proposed management models that pro-whaling countries are wishing to use for a resumption of commercial whaling. As the IWC moves rapidly towards a pro-whaling majority membership, Australia's role is increasingly important if whales are to be protected from renewed over-exploitation.

Opportunity: Enhance international whale protection through science-based ecological arguments.

Genomics

There is a pressing need to improve our knowledge of the present genetic species and community biodiversity of Antarctica and to ascertain how the past has shaped the present biodiversity. We do not know how Antarctic organisms and ecosystems respond to environmental change. There are fundamental questions about whether gene pools of Antarctic organisms are as disparate as those in lower latitudes. If they are more homogeneous, the consequences of even subtle climate change could be quite dramatic. What changes in biodiversity can be expected is a key issue to be addressed.

The field of bioinformatics, where data on the genomes of any species that exist on the public databases can be interrogated, is proving to be a powerful tool to address these issues. The outcomes are only as good as the databases, however, and as yet genome analysis of Antarctic species has been limited. It is critical that work begin on the genome of some sentinel species as soon as practicable.

Opportunity: Understand and safeguard the biodiversity of the unique Antarctic ecosystems through application of advanced genomics.

Bioprospecting

Bioprospecting (biological prospecting) concerns searching for chemical compounds of biological activity, or useful gene sequences in wild organisms, including micro-organisms. Australian researchers have undertaken little research in this emerging field. The creation of the multi-disciplinary research programme on "Adaptation to Environmental Change" should provide the focus for the development of studies focusing on the specific biochemical and genetic modifications that enable Antarctic organisms to exist in the harshest environment on Earth.

World-wide some 40 patents have been registered for products derived from Antarctic organisms.

Opportunity: Search for biologically active compounds.

2.5 Astronomy

Conditions for operating optical and infrared instruments for astronomical research in Antarctica are optimal on the high inland plateau. Here the atmosphere is drier, colder and more stable than anywhere else on the planet. These attributes offer enormous gains in sensitivity for an Antarctic telescope over one at a mid-latitude site. The Australian astronomy community is hoping to join one of the international consortia currently working towards the development of an Extremely Large Telescope (ELT), one of the next generation optical/infrared telescopes with a mirror diameter 20-100 metres across, with 6 to 100 times the light-gathering power of today's 8 metre telescopes. These matters were discussed in a previous report to PMSEIC on 17 June 2004 called *Future Opportunities for Australian Astronomy*.

Participation in an international consortium would require considerable funding in addition to that provided for the existing Australian Antarctic Programme. Such funding would need to be considered in the context of Australia's overall astronomy and astrophysics research efforts and priorities.

Opportunity: To obtain a share of the world's next generation of optical/infrared telescopes.

2.6 Tourism

The tourism industry in Antarctica has developed significantly over the past 10 years with an annual growth of approximately 20% in the number of tourist visits. There are now more tourists visiting Antarctica than national programme personnel, although the time they spend in Antarctica is significantly shorter. The growth in tourism poses many challenges to Antarctic Treaty Parties, particularly in relation to the management of potential environmental impacts. Though Australia is leading research to minimise the impacts of tourism in Antarctica, the growth in tourism exceeds the rate of our learning about its impacts. Monitoring of cumulative impacts of tourists is particularly difficult due to the lack of base-line data on which to make assessments. There is a pressing need for additional research to provide us with the information with which to manage these activities.

Opportunity: Ensure that the growth in Antarctic tourism has minimum impact by undertaking research into the management of potential environmental impacts.



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3 A VISION FOR THE FUTURE

Australia will lead the world in key areas of Antarctic and Southern Ocean science over the next 15 years. Our position as a large developed nation in the Southern Hemisphere gives us a unique opportunity and responsibility to provide international leadership in Antarctic science, as we have done for the past 100 years.

We believe that, over the next 15 years, Australian scientists will be well placed to provide leadership in the key areas of ice, ocean, atmosphere and biodiversity, and through that create the ability for Australia to benefit from:

- Better forecasting of weather and climate;
- Understanding and conserving Antarctic and Southern Ocean biodiversity;
- Economic rewards from fisheries, biotechnology and tourism.

3.1 Better forecasting of weather and climate

Thirty years ago, the introduction of routine observations from Southern Ocean data buoys led to a significant improvement in Australian and Southern Hemisphere weather forecasting. Over the coming fifteen years, a greatly enhanced observing system across Antarctica and the Southern Ocean will provide the basis for more reliable and longer lead-time prediction of weather and climate. Australian expertise in meteorology and oceanography, based on state-of-the-art observation, analysis and modelling, will underpin, and guide, the development of global systems for more accurate short to medium range weather forecasts, more reliable seasonal to inter-annual prediction of the natural fluctuations of climate and improved assessments of the nature and extent of long-term changes in climate due to human influence.

3.2 Understanding and conserving Antarctic and Southern Ocean biodiversity

The adaptive management of the ocean's resources and the development of effective and innovative management plans for areas over which we have jurisdiction, such as the Heard and McDonald Island Marine Reserve, is a priority. Through an understanding of the biodiversity of Antarctica and the Southern Ocean we will continue to play a leading role in the forums where international agreement is reached.



3.3 Economic rewards from fisheries, biotechnology and tourism

Better management of the Southern Ocean will result in sustainable harvested resources and greater economic return to the nation. Many economic benefits of our engagement in Antarctica remain largely unrealised, although tourism, fisheries and biotechnology are growing. The rewards are potentially great. The Southern Ocean contains the largest unexploited resource of marine protein, which may become crucial for supplying feed to the booming global aquaculture industry. The Southern Ocean has yet to reveal its stock of novel compounds derived from organisms adapted to the extreme Antarctic environment. Our science will ensure the nation can benefit from new Antarctic industries while safeguarding the environment. Biotechnological potential from Southern Ocean organisms will be developed, in partnership with Australian industry.



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Wayne Papps © AAD



Christo Baars © AAD

4 ACHIEVING THE VISION: THE NEXT 15 YEARS

To achieve the vision, we must focus the Australian Antarctic science effort on the key areas outlined above. This will require us to concentrate our efforts in four main areas.

4.1 The International Polar Year

Just as the International Geophysical Year did 50 years ago, the International Polar year (2007-08) provides a unique opportunity for a major step forward in our understanding of Antarctica and a platform for the further scientific programmes that will enable us to achieve our vision over the next fifteen years. Australia is well placed to provide a lead in opening up new frontiers of Antarctic knowledge and attracting increased international research resources to Australia.

Recommendation 1: Undertake a period of enhanced scientific activity for the International Polar Year to advance our research by leveraging off the activities of the international partners in the programme.

4.2 An air-link to Antarctica

With the establishment of an inter-continental air-link and enhanced intra-continental air transport, many more of our scientists will be able to access field sites in Antarctica and new science avenues will be opened up. Implementation of the proposed Antarctic air transport system will enable the great wealth of research talent in our Universities and research agencies to participate in the programme. It will remove the last impediment that is already causing some Australian scientists to join the Antarctic programmes of other nations (who have air transport). An air transport system will provide the flexibility and responsiveness that an innovative future Antarctic programme requires.

An air-link will allow for an efficiency of operation comparable to that enjoyed by other major Antarctic nations and, by freeing up ships from their current passenger ferry activities, enable a greater emphasis on marine science. Training the next generation of Antarctic scientists will be greatly advanced through the ready access of supervisors to students and field sites. It will facilitate airborne geophysical research and will enable scientists to study the atmosphere over the Southern Ocean on a regular basis. Increased participation by scientists from other countries in Australia's programme can confidently be expected, bringing increased flow of expertise and research money through Australia as a gateway to Antarctica.

Air transport will ensure that Australia remains innovative and influential in the Antarctic Treaty System.

Recommendation 2: Implement an air transport system from Australia to Antarctica to complement the existing shipping program and the developing intra-continental air transport system in Antarctica.

4.3 Earth observation

In situ land and sea-based observations of Antarctica and the Southern Ocean grow more important with time. Remote sensing and robotic exploration lowers the costs and increases the density and frequency of observations, but field observation remains essential for “ground-truthing” and experimentation. We will require an operational Southern Ocean observing system, and continued access to upgraded ice-based and land-based meteorological observations. These field and automated observations will complement satellite data which we currently obtain from other nations under internationally coordinated programmes such as the World Weather Watch, the Global Ocean Observing System and the Global Climate Observing System. While Australia benefits significantly from such programmes, its contribution of *in situ* observations, its participation in international research activities and its involvement in the development and administration of such programmes provide the basis for Australia to achieve the maximum benefit from the emerging Global Earth Observation System of Systems (GEOSS).

Recommendation 3: Play a leadership role in developing and implementing a Southern Ocean observing system and the next generation of *in situ* data-gathering instrumentation for use in Antarctica and remote locations.

4.4 Institutional arrangements for research

Implementing our vision for leadership in key areas of Antarctic and Southern Ocean science will require a stable and long-term collaborative research framework, building on the Antarctic Climate and Ecosystems Cooperative Research Centre (ACE CRC) which has brought together the Australian Antarctic Division, CSIRO, the Bureau of Meteorology, Australian universities through the wider Antarctic research programme and some international partners to great effect. This platform is essential if we are to continue to engage our universities and other research agencies most effectively and provide a key focus for our international collaborations, particularly if an air link and suite of dedicated Southern Ocean exploration voyages is to be realised.

An example of collaborative Australian Antarctic research is with French scientists on fisheries. This concerns a key emerging issue about the harvesting of toothfish on the Kerguelan Plateau. A collaborative project is planned to include a joint trawl survey, fish tagging and genetic analysis under the recently signed Australian/French Cooperation Treaty.

Recommendation 4: Secure stable long-term institutional arrangements for collaborative Antarctic research across all fields of biology, geology, glaciology, meteorology and oceanography.

4.5 Conclusion

Our science, and that of our predecessors, has given our nation a high profile and much international influence within the Antarctic Treaty system. Recent reviews of its quality indicate that we have leadership roles in key areas and have hard-won gains upon which an exciting future can be built. The International Polar Year provides an opportunity for us to show our leadership in significant international programmes which will provide vital information of direct value to the Government's environmental and Antarctic goals. Continued Government support will strengthen the benefits that the Antarctic Programme already provides to Australia. An increase in Government support for Antarctic science (including support for logistics and infrastructure) will maximise Australia's scientific return providing new scientific, economic, social, environmental and international relations benefits in such areas as:

- improved weather and climate forecasting;
- an economically viable and sustainable fishing industry;
- leadership in environmental practices;
- health benefits (immunology, microbiology, psychology);
- patents from biotechnology discoveries;
- greater collaboration with national and international organisations;
- and
- consolidation of our international standing.

We want our nation to be as proud of its future in Antarctica as it is of its past.



APPENDIX 1

Terms of Reference of the Working Group

The Working Group will prepare a paper and presentation for PMSEIC on *the opportunities for Antarctic and Southern Ocean Science* to:

- 1) Draw up a profile of our scientific infrastructure in Antarctic and Southern Ocean science. Describe Australia's role in Southern Ocean monitoring and research.
- 2) Identify and raise awareness of newly emerging areas of Antarctic and Southern Ocean science (observation, research and application) in which Australia has a key role to play, taking into account existing priorities and emerging needs and opportunities.
- 3) Evaluate the potential for an improved contribution by Australia to understanding the role of Antarctica and the Southern Ocean in major global issues such as climate change.
- 4) Examine the scope for greater collaboration between scientific bodies interested in Antarctic and Southern Ocean research and other mainstream funding bodies, including international ones.
- 5) Flag issues such as sovereignty, security peace and harmony in the South and natural resource management, among others. Show how science enhances Australia's strategic interests and claim. Take a hard look at these competing policy and scientific issues and provide views on the future.

APPENDIX 2

Working Group

- **Dr John Zillman** (Chair)
President, Australian Academy of Technological Sciences and Engineering - PMSEIC Member
- **A/Professor Matthew England**
Director, Centre for Environmental Modelling and Prediction, University of New South Wales.
- **Dr Tony Haymet**
Chief of Commonwealth Scientific and Industrial Research Organisation Marine Research
- **Professor Kurt Lambeck**
Chair, Antarctic Science Advisory Committee
- **Dr Mike Manton**
Chief Scientist, Bureau of Meteorology
- **Professor Bruce Mapstone**
Chief Executive Officer, Antarctic Climate and Ecosystem Cooperative Research Centre
- **Dr Tony Press**
Director, Australian Antarctic Division
- **Professor Marilyn Renfree**
Federation fellow and Laureate Professor, Department of Zoology, University of Melbourne
- **Professor Michael Stoddart**
Chief Scientist, Australian Antarctic Division
- **Professor John White**
Research School of Chemistry, Australian National University
- **Dr Neil Williams**
Chief Executive Officer, Geoscience Australia

APPENDIX 3

Glossary of terms

AAD	Australian Antarctic Division
AAT	Australian Antarctic Territory
ACC	Antarctic Circumpolar Current
ACE CRC	Antarctic Climate and Ecosystems Cooperative Research Centre
ASAC	Antarctic Science Advisory Committee
BoM	Bureau of Meteorology
CAML	International Census of Antarctic Marine Life
CCAMLR	Convention for the Conservation of Antarctic Marine Living Resources
CSIRO	Commonwealth Scientific and Industrial Research Organisation
ELT	Extremely Large Telescope
GEOSS	Global Earth Observation System of Systems
ICSU	International Council for Science
IGY	International Geophysical Year
IPCC	Intergovernmental Panel on Climate Change
IPY	International Polar Year
IWC	International Whaling Commission
(The) Madrid Protocol	The Annex on Environmental Protection to the Antarctic Treaty
NASA	United States' National Aeronautics and Space Administration
PMSEIC	Prime Minister's Science, Engineering and Innovation Council
UNCLOS	United Nations Convention on the Law of the Sea
WMO	World Meteorological Organization

APPENDIX 4

Areas of extended continental shelf submitted by Australia to the Commission on the limits of the Continental Shelf

The 'Law of the Sea' is a body of international rules and principles developed by States to regulate ocean space, as reflected in the 1982 United Nations Convention on the Law of the Sea (UNCLOS). Australia participated in all three United Nations conferences on the Law of the Sea (1958, 1960 and 1973-82) and became party to UNCLOS in 1994.

An international agreement about the sea became necessary when many nations realised the wealth of resources there - especially fisheries and mineral resources. These marine resources are not endless and need effective and sustainable management.

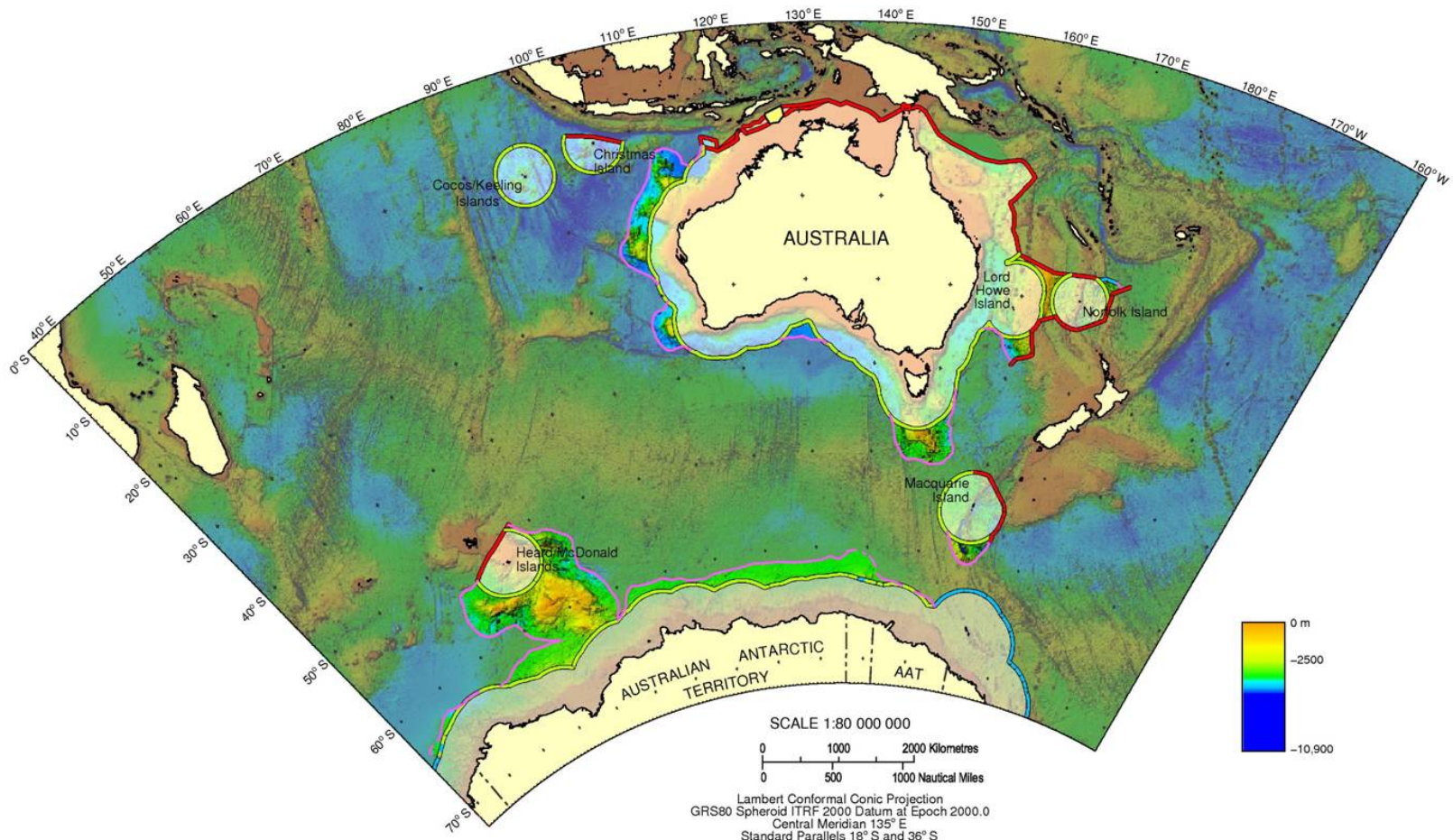
All of the countries bound by UNCLOS must follow rules about marine boundaries, access to the various marine zones, and managing the resources and activities within those boundaries. All member countries of the United Nations are eligible to become party to UNCLOS, whether or not they have a coast. During the drafting of UNCLOS, the needs of land-locked countries were taken into account.

In accordance with Article 57 of UNCLOS, Australia has an Exclusive Economic Zone that extends beyond the 12 nautical mile territorial sea to a distance of 200 nautical miles in most places. The Exclusive Economic Zone (EEZ) gives Australia jurisdiction over the water column, seabed and subsoil in a marine area of some 10 million square kilometres. This area is considerably larger than that of the Australian continent (7.7 million square kilometres).

In some places, Australia's continental margin extends further out than 200 nautical miles from the territorial sea baseline from which the EEZ is measured. Under article 76 of UNCLOS, Australia has the right to make a submission to the United Nations Commission on the Limits of the Continental Shelf (CLCS) to delineate the outer limits of these areas of "extended" continental shelf. This delineation is largely a scientific task and has been undertaken by Geoscience Australia with the assistance of the Department of Foreign Affairs and Trade, the Attorney General's Department, the Department of the Environment and Heritage, the Department of Finance and Administration and the Australian Hydrographic Service (Department of Defence).

Australia's submission for areas of extended continental shelf was lodged with the CLCS on 15 November 2004. It will be initially considered by the Commission at its 15th session in April 2005 before recommendations are made back to Australia at a later stage.

The map below shows the areas of extended continental shelf as submitted by Australia to the CLCS in November 2004.



Lines

- 200 M line from Australia's territorial sea baseline
- 200 M line off an opposite or adjacent State
- 200 M line off Antarctica - in areas of potential delimitation
- Treaty boundary with an opposite or adjacent State
- Outer limit of extended continental shelf
- Outer limit of extended continental shelf in areas of potential delimitation off Antarctica
- Land boundary with an adjacent State
- Land
- Joint Petroleum Development Area as defined in the Timor Sea Treaty between Australia and Timor-Leste

SCALE 1:80 000 000
 0 1000 2000 Kilometres
 0 500 1000 Nautical Miles
 Lambert Conformal Conic Projection
 GRS80 Spheroid ITRF 2000 Datum at Epoch 2000.0
 Central Meridian 135° E
 Standard Parallels 18° S and 36° S

APPENDIX 5

Profile of Resources for Antarctic and Southern Ocean Research and Observations

The major research bodies involved in Antarctic and Southern Ocean research and observations are:

- Australian Antarctic Division
- Antarctic Climate and Ecosystems Cooperative Research Centre
- Bureau of Meteorology
- CSIRO
- Australian universities – over 50 research projects are supported annually by the Australian Antarctic Science Grants scheme.

Total annual support from the Australian Government for this scientific work is estimated to be over \$100 million.

Twenty five nations and over one hundred research institutions also contribute to Australia's scientific interests and activities in Antarctica, many through the provisions of semi-formal instruments. This draws into Australian Antarctic science much cooperation and the additional expertise of scientists from overseas universities and other research bodies.

The Australian Antarctic Division (AAD) is the central agency that coordinates and provides logistical support for the research bodies named above that perform work in Antarctica. Nearly half of the AAD budget comprises logistic support of ships and aircraft, together with station and field infrastructure support. Scientific research conducted within AAD accounts for 15% of its budget. AAD provides the core strategic, policy, operational and scientific resources necessary to achieve the Government's goals for the Antarctic.

The CRC receives just over \$3 million annually, on average, from the Australian Government. This is for a period of seven years, starting July 2003 (total \$23.54m). Its partners provide further funding for the activities of the Centre.