Australian Antarctic Science Program Highlights 2022-23

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**Information Paper submitted by Australia**

Summary

Australia operated a successful Antarctic science program in 2022-23. Forty-seven projects were supported, across multiple disciplines and through strong collaboration with Australian and international research programs and institutions. Research highlights include: retrieval of the first test ice cores from the site of the Million Year Ice Core Project; participation in the International Year of Polar Prediction – Southern Hemisphere (YOPP-SH), with Davis station acting as the East Antarctica super site; establishment of a field camp in the Bunger Hills to support the upcoming Denman Terrestrial Campaign; and field work at Australia’s three continental stations to support ongoing climate science, wildlife monitoring, and environmental protection and management.

Overview

The Australian Antarctic Science Program (AASP) is made up of Australian Government agencies and Australian and international universities and research institutions. In 2022/23 the program undertook 47 science projects across multiple disciplines. Well over 50 per cent of these projects included international collaborations across 23 countries. The AASP continues to benefit enormously from national and international research and operational collaborations.

The program has a strong focus on research designed to inform the protection and management of Antarctica. This includes research that contributes to understanding and addressing regional and global issues through international organisations such as the Committee for Environmental Protection (CEP) and Antarctic Treaty Consultative Meeting (ATCM), the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR), the Intergovernmental Panel on Climate Change (IPCC), the International Whaling Commission (IWC), and the Agreement on the Conservation of Albatrosses and Petrels (ACAP).

The Australian Antarctic Division (AAD) of the Department of Climate Change, Energy, the Environment and Water leads, manages and coordinates the AASP with oversight provided by the Australian Antarctic Science Council. Public summaries of all science projects, past and present, are available on the [AAD website](https://secure3.aad.gov.au/public/projects/).

In 2022, two new programs were initiated at the AAD – the East Antarctic Monitoring Program (EAMP) and the Integrated Digital East Antarctica Program (IDEA). EAMP will provide a framework for sustained, long-term scientific observations of essential biological and physico-chemical variables in East Antarctica and the Southern Ocean. IDEA will facilitate and coordinate the acquisition, integration, analysis, synthesis and delivery of Antarctic and Southern Ocean data and data products, providing seamless access to multiple and integrated sources of data and data products to underpin science and inform decision making. Both initiatives will facilitate collaboration and cooperation nationally and internationally.

Work is currently underway to develop a decadal plan for Australian Antarctic science. The decadal plan will establish a strategically prioritised, integrated and collaborative Australian Antarctic Science Program and will:

* articulate the priority science questions and policy needs to be addressed by Australian Government supported research over the next 10 years;
* identify the research programs that will be conducted to address these priorities; and
* assess the existing and required capabilities to address these priorities, identifying any gaps, and developing plans to fill these gaps, and setting out agreed deliverables, timelines, performance measures and responsibilities.

The decadal plan is expected to be completed by the end of 2023.

Research Highlights 2022-23

Million Year Ice Core project

Australia completed the first journey to the drill site for the Million Year Ice Core project, at Little Dome C, 1200 km inland from Casey station at an elevation of 3200 m. The team proved a safe 2300 km round trip path to the site while testing the tractors and traverse machinery required to transport all the people and equipment. The team also successfully collected the first ice cores, representing the climate record over the past 200 years, which were successfully flown back to Australia without degradation or defrosting. The 2023-24 season will see drilling begin to retrieve an ice core to an ultimate depth of 2.8 km. This project will provide new information to test climate models and resolve long-standing questions about the timing of ice ages. Further information about the project is available [the AAD website](https://www.antarctica.gov.au/science/climate-processes-and-change/antarctic-palaeoclimate/million-year-ice-core/).

Personas paradas en la nieve

Descripción generada automáticamente

*Test drilling for the Million Year Ice Core Project at Little Dome C. (Photo: AAD)*

Preparations for Denman Terrestrial Campaign

A field camp was established at Edgeworth David Base, 440 km west of Casey station in the Bunger Hills, near the Denman Glacier. Commencing next season, the camp will support the three-year Denman Terrestrial Campaign, which will address key research questions including the risk of ice mass loss over time and the responses of biodiversity to climate and environmental change. Further information about the project is available on the [AAD website](https://www.antarctica.gov.au/science/climate-processes-and-change/antarctic-palaeoclimate/denman-terrestrial-campaign/).

Contribution to International Year of Polar Prediction

The AAD contributed to the International Year of Polar Prediction – Southern Hemisphere (YOPP-SH) co-ordinated field campaign around Antarctica from April – August 2022, with Davis station acting as the East Antarctica supersite. One of the YOPP-SH goals is to challenge numerical prediction models by presenting them with detailed cloud and snowfall observations. A suite of instruments operated at Davis collected data for this purpose. These data will be used to evaluate and improve the performance of high-resolution models for the Davis region.

Marine acoustics research

The annual recovery and deployment of a moored acoustic recorder (MAR) off Casey station was successfully completed. This marked the AAD's 10th consecutive year of long-term autonomous underwater acoustic monitoring off East Antarctica, and the 15th year of data collection. The hundreds of thousands of hours of Antarctic underwater sounds recorded by these moorings, and those of international collaborators, are one of IWC’s primary modern data sources for critically endangered Antarctic blue whales, and also provide valuable information on a dozen other Antarctic animals. The data also provide a means of monitoring for trends in sounds of ice, storms, and human activities including shipping and geophysical surveys. Australia’s present fleet of Antarctic MARs were designed, built, and have been operated by AAD Science Technical Support since 2013.

Australian Research Council Special Research Initiatives – SAEF and ACEAS

A *Securing Antarctica’s Environmental Future* (SAEF) project team used drones, artificial intelligence and machine learning over two months at Casey station to develop improved methods to monitor the moss beds that have been shown to be declining in general health over the past 20 years. The new technology included a world-first state-of-the-art monitoring platform, the “Artificial Intelligence of Things” (AIoT) platform, which allows for continuous images of the moss beds, air and moss temperatures, light intensity, humidity and soil-air energy exchange to be transmitted to Australia. This work forms part of a broader program continuing next season in the Bunger Hills as part of the Denman Terrestrial Campaign. A team from the SAEF program also worked on Macquarie Island sampling the lakes, soils, invertebrates, taking peat cores and surveying critically endangered and invasive plant species to inform the remote sensing work being undertaken as part of the broader project.

Scientists with the *Australian Centre for Excellence in Antarctic Science* (ACEAS) deployed seismometers in defined configurations at locations close to Casey station to collect data to inform ice-sheet-bedrock interface zone models. This will help improve understanding of how changes in Antarctic ice sheets may impact sea-level rise and will be expanded in the following seasons at the Denman Glacier and further inland.

Long-term monitoring

The Australian Antarctic Program continued its focus on maintaining long term monitoring projects, many of which employ technology solutions to ensure the automated collection of data. Examples include:

* cosmic ray monitoring using neutron monitors and muon telescopes at Mawson station and Kingston, Tasmania, to contribute to international databases and space weather warning systems
* collecting year-round and multi-year datasets using a network of GPS and seismic monitors to provide information on the internal structure of the solid earth deformation and structure in East Antarctica
* monitoring of Antarctic breeding seabirds through a network of remotely operating time-lapse cameras
* sea level determination using tide gauges deployed at all three Australian continental stations and one subantarctic station
* greenhouse gas monitoring at two Australian continental stations and one sub Antarctic station to contribute to the most extensive atmospheric composition observational network in the region.

Krill Aquarium

Plans to establish a new world-leading Antarctic krill aquarium and research facility in Tasmania advanced. The AAD, in cooperation with the University of Tasmania will construct a Southern Ocean research aquarium in Hobart, expanding upon one of the world’s only Antarctic krill aquarium research facilities at the AAD. The exciting new laboratory will provide a sophisticated experimental research platform to understand future impacts of climate change on the krill to meet a key commitment in the *Australian Antarctic Strategy and 20 Year Action Plan.*

Publication Highlights

A number of significant manuscripts were published during the period, with highlights including:

1. Lee JR, Terauds A, Carwardine J, Shaw JD, Fuller RA, Possingham HP, … McIvor E, … Bergstrom DM, et al. (2022) Threat management priorities for conserving Antarctic biodiversity. *PLoS Biol* 20(12): e3001921. <https://doi.org/10.1371/journal.pbio.3001921>

An Australian led multi-national research project culminated in this recent publication. This study found that up to 65% of Antarctic terrestrial species (or species groups) are likely to decline by 2100. It highlighted the potential impact of climate change and showed that simultaneously pursuing global and regional management actions will provide the best chance of protecting Antarctica’s terrestrial biodiversity into the future. See Information Paper 45 *Managing threats to Antarctic terrestrial biodiversity*.

1. Pedro, JB, et al., (2022). Dansgaard-Oeschger and Heinrich event temperature anomalies in the North Atlantic set by sea ice, frontal position and thermocline structure. *Quat.Sci.Rev* 289, 107599, <https://doi.org/10.1016/j.quascirev.2022.107599>.

This study advances our understanding of abrupt climate changes during the last glacial period, specifically around the roles of sea ice extent, ocean front position and thermocline structure in the spatiotemporal pattern of climate changes. While the study has a northern hemisphere focus there are far-field impacts on millennial-scale climate change at southern high latitudes.

1. Poppelmeier F, Baggenstos D, Grimmer M, Liu Z, Schmitt J, Fischer H, Stocker T (2023) The effect of past saturation changes on noble gas reconstructions of mean ocean temperature. *Geophysical Research letters* 50: e2022GL102055 <https://doi.org/10.1029/2022GL102055>

This modelling studed tests some of the assumptions that are usually made when using the mean ocean temperature proxy based on noble gases in ice cores. The model explicitly simulated noble gases in the ocean and allowed an assessment of how changes in wind, sea ice, and circulation impact the saturation state of the gases. The study found that noble gas saturation potentially varied significantly in the past, which needs to be taken into account when applying the mean ocean temperature proxy.

1. [Suter L.](https://kgs-apps-int-dmz.aad.gov.au/public/pubn/search.cfm?action=lookup&author=Suter%20L%2E), [Wotherspoon SJ](https://kgs-apps-int-dmz.aad.gov.au/public/pubn/search.cfm?action=lookup&author=Wotherspoon%20S%2EJ%2E), [Kawaguchi S](https://kgs-apps-int-dmz.aad.gov.au/public/pubn/search.cfm?action=lookup&author=Kawaguchi%20S%2E), [King R](https://kgs-apps-int-dmz.aad.gov.au/public/pubn/search.cfm?action=lookup&author=King%20R%2E), [MacDonald AJ](https://kgs-apps-int-dmz.aad.gov.au/public/pubn/search.cfm?action=lookup&author=MacDonald%20A%2EJ%2E), [Nester GM](https://kgs-apps-int-dmz.aad.gov.au/public/pubn/search.cfm?action=lookup&author=Nester%20G%2EM), [Polanowski AM](https://kgs-apps-int-dmz.aad.gov.au/public/pubn/search.cfm?action=lookup&author=Polanowski%20A%2EM%2E), [Raymond B](https://kgs-apps-int-dmz.aad.gov.au/public/pubn/search.cfm?action=lookup&author=Raymond%20B%2E), [Deagle BE](https://kgs-apps-int-dmz.aad.gov.au/public/pubn/search.cfm?action=lookup&author=Deagle%20B%2EE%2E) (2023) Environmental DNA of Antarctic krill (*Euphausia* *superba*): Measuring DNA fragmentation adds a temporal aspect to quantitative surveys. Environmental DNA 00:1-15 <https://onlinelibrary.wiley.com/doi/10.1002/edn3.394>.

This study aimed to enhance environmental DNA (eDNA)-based monitoring of Antarctic krill to complement conventional krill surveys. Antarctic krill eDNA could be quantified in addition to estimating a relative time since shedding (“recent” vs “older”). The method developed could not only determine where Antarctic krill eDNA is present but sheds light on how krill may be using certain habitats, expanding our understanding of this important species’ life cycle and contributing to more accurate abundance and distribution estimates.

1. Emmerson L, Southwell C (2022) Environment-triggered demographic changes cascade and compound to propel a dramatic decline of an Antarctic seabird metapopulation. *Global Change Biology* 28:7234-7249 <https://doi.org/10.1111/gcb.16437>.

This study interrogated key demographic parameters and their biophysical drivers to understand the role of intrinsic and extrinsic processes during a recent near halving of a large Adélie penguin (*Pygoscelis adeliae*) metapopulation. The loss of 154,000 breeding birds along the 100-km East Antarctic coastline centred around 63°E over the last decade diverges from a sustained increase over preceding decades and is contrary to recent models that predict a continued increase. The study showed that failure to capture both intrinsic and extrinsic drivers in predictive population models may mean that the real impacts of climate change on species' populations are more severe than projections would lead us to believe.

1. Stark JS. (2022) Effects of lubricant oil and diesel on macrofaunal communities in marine sediments: A five-year field experiment in Antarctica. *Environmental Pollution* 311:119885. <https://pubmed.ncbi.nlm.nih.gov/35977637/>

This study involved a controlled field experiment in a shallow Antarctic marine embayment to investigate the effects of four different hydrocarbon products (diesel fuel and three lubricating oils) on sediment macrofaunal communities in the Antarctic near-shore marine environment. The experiment showed that the impacts of spilled hydrocarbons in Antarctica will persist well beyond five years, but diesel impacts will recover faster than oil.

1. Cox MJ, Macaulay G, Brasier MJ, Burns A, Johnson OJ, King R, [Maschette D](https://kgs-apps-int-dmz.aad.gov.au/public/pubn/search.cfm?action=lookup&author=Maschette%20D%2E), [Melvin J](https://kgs-apps-int-dmz.aad.gov.au/public/pubn/search.cfm?action=lookup&author=Melvin%20J%2E), [Smith AJR.](https://kgs-apps-int-dmz.aad.gov.au/public/pubn/search.cfm?action=lookup&author=Smith%20A%2EJ%2ER%2E), [Weldrick CK](https://kgs-apps-int-dmz.aad.gov.au/public/pubn/search.cfm?action=lookup&author=Weldrick%20C%2EK%2E), [Wotherspoon SJ](https://kgs-apps-int-dmz.aad.gov.au/public/pubn/search.cfm?action=lookup&author=Wotherspoon%20S%2EJ%2E), [Kawaguchi S](https://kgs-apps-int-dmz.aad.gov.au/public/pubn/search.cfm?action=lookup&author=Kawaguchi%20S%2E) (2022) Two scales of distribution and biomass of Antarctic krill (Euphausia superba) in the eastern sector of the CCAMLR Division 58.4.2 (55°E to 80°E). PLoS ONE 17(8): e0271078. <https://doi.org/10.1371/journal.pone.0271078>

This study provides a biomass estimate for Antarctic krill in the eastern sector of the CCAMLR Division 58.4.2 using data collected during an acoustic-trawl survey carried out in February and March 2021. The biomass density was estimated as 8.3 gm-2 giving a total areal krill biomass of 6.48 million tonnes. The study assessed the efficacy of extrapolating smaller surveys to a wider area.

1. Thompson SS, Kulessa B, Luckman A, Halpin JA, Greenbaum JS, Pelle T, Habbal F, Guo J, Jong LM, Roberts JL, Sun B, and Blankenship DD (2023) Glaciological history and structural evolution of the Shackleton Ice Shelf system, East Antarctica, over the past 60 years, *The Cryosphere* 17:157–174 <https://tc.copernicus.org/articles/17/157/2023/tc-17-157-2023.html>

This paper seeks to better understand the controls driving Denman Glacier's dynamic evolution by focussing on the Shackleton system, comprised of the Shackleton Ice Shelf, Denman Glacier, and the adjacent Scott, Northcliff, Roscoe and Apfel glaciers, about which almost nothing is known. This study draws on 60 years of observations and integrating new satellite observations of ice structure and airborne radar data with changes in ice front position and ice flow velocities. Over the period 2017–2022 the study found a significant increase in ice flow speed (up to 50 %) on the floating part of Scott Glacier, coincident with small-scale calving and rift propagation close to the ice front.