Leading Australian Antarctic Science

Review of Australian Antarctic Division Science Branch

November 2021

Mr Kim Ellis
Director
Australian Antarctic Division
Department of Agriculture, Water and the Environment

Dear Mr Ellis

Report – Review of AAD Science Branch

In September 2021 you commissioned a Review to understand the quality, relevance and impact of the science conducted by the AAD's Science Branch, in the context of Antarctic science being conducted elsewhere in Australia and the world; and you engaged a panel of nine people to conduct the Review. The panel now submits the report of its Review.

The Review makes 11 recommendations for change. The key recommendations are that the Division adopt as its core value that science is at the centre of all its activities and that a Decadal Plan for Australian Antarctic and Southern Ocean science be developed to ensure a comprehensive approach to identifying, prioritising, conducting and applying research. Other recommendations cover the role of Science Branch, and science collaboration, capability, logistics support and communication. There are recommendations for an Integrated Digital East Antarctica (IDEA) initiative and a formal, long-term East Antarctica Monitoring Program (EAMP), and a recommendation to help with implementation of the Review.

The recommendations are practical mechanisms for ensuring that AAD's Science Branch contributes to a coherent, active, world-leading Australian Antarctic Program that meets Government policy objectives in Australia's national interest and plays a major role in addressing big international science challenges. Implementation will result in Australian Antarctic Program science that should, within three years, work collaboratively, constructively and creatively, and demonstrably lead critical initiatives.

The panel appreciates the considerable assistance it was given. It thanks all those who spoke with panel members at interviews. These included representatives of many agencies in Australia and internationally and stakeholders from across the Antarctic and Southern Ocean research sector, staff members from across the Division, and staff members within the Science Branch. It particularly thanks Science Branch staff for the very detailed materials they provided, and their time in presenting and talking to the panel.

Mary O'Kane
Chair, Review Panel
12 November 2021

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Executive Summary

Australia asserts sovereignty over 42% of the Antarctic continent, in the region known as East Antarctica, a claim which is of strategic importance to the nation. This assertion, and its related maritime claims, is maintained by Australia's occupation of, and the conduct of science to monitor, understand and predict the behaviour of, East Antarctica, and by its active participation in the international Antarctic Treaty System.

It is often stated that 'science is the currency of Antarctica' which reflects Articles II and III of the Treaty. Much Antarctic and Southern Ocean science is undertaken in Australia, most of it under the national umbrella of the Australian Antarctic Program (AAP).

The Australian Antarctic Division (AAD), in the Department of Agriculture, Water and the Environment (DAWE), is responsible for leading, coordinating and delivering the Australian Antarctic Program and administering the Australian Antarctic Territory (and, in the subantarctic, the Territory of Heard Island and McDonald Islands, a World Heritage site for which Australia has international responsibilities). A lot of the AAD's work involves providing access to, and coordinating the logistics and operational aspects of, much of the Australian travel to and presence in the AAT. It also leads science-related policy advice to the Australian Government, and its Science Branch conducts a range of Antarctic and Southern Ocean science and activities. It also allocates access to infrastructure such as the icebreaker RSV *Nuyina*.

The Review was commissioned by the Director of the AAD, Mr Kim Ellis, to consider the quality, impact and relevance of science in the Science Branch, in light of the appointment of a new Chief Scientist, Professor Nicole Webster, to head the Branch.

Members of the Review panel consulted widely. Internationally, interviews were held with representatives of some of the premier international Antarctic science bodies, including with members of the Scientific Committee on Antarctic Research (SCAR), and with representatives of other polar programs. In Australia, interviews were held with Ministers in the Australian and Tasmanian governments, and representatives of government agencies, industry and the Antarctic science community, including Division and Science Branch staff.

The Review concluded there were significant positive opportunities to improve the direction, support, resourcing and delivery of world class science from the Branch and to reassert the Australian Antarctic Program as a global, top-tier, national Antarctic program. It was evident the combined challenges from insufficient planning and direction, exacerbated by resourcing constraints and multiple leadership changes in recent years, have taken their toll on the culture, outputs, and scientific excellence of the Science Branch.

Overall, the Review assesses the quality and impact of Science Branch's output as mixed. Much of the Branch's science cannot be regarded as addressing high priority Antarctic science questions, such as the '80 most important scientific questions' identified in the SCAR Horizon Scan of 2014 and updated in 2019. It was noted by the Review that SCAR was not mentioned in the Australian Antarctic Strategic Plan, an omission that is possibly indicative of the lack of scientific direction.

Good work of world standard with high impact is being done in the areas of sea ice, ice sheets and ice cores. Good practical science that is directed to end-user needs includes insurance-funded remediation work supported by environmental toxicology; fisheries work which informs sustainable fisheries; and ecological work done to support obligations or policy advice required under the Antarctic Treaty System, in particular the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR). Some science lays the foundation for possible large, interdisciplinary programs that address pressing societal needs (e.g. global warming, sea level rise, ocean acidification, loss of biodiversity, etc.) in the future – for example, the successful closing of the krill life cycle in aquaria would underpin a much bigger project on developing ecosystem models of the ecology of the Southern Ocean. Some science has high quality aspects, but is not well connected to related major initiatives, e.g. the atmospheric research. Some smaller groups in other areas

do good research but lack the critical mass to tackle 'high priority' issues. And some research is not of good quality or reflective of best current practice.

The Review noted that many Branch scientists appear to have only a general idea of why they, and the Branch, are doing the research they do. It is clear to the Review that there has been a long-term lack of consistent direction in the Branch. This is evident from the lack of a clear strategy underpinning the Branch's science and the lack of a clear planning process for the future, including regular performance assessment, staff development and succession. No one seems to own the research agenda as a whole. This lack of consistent direction seems to have led to a Branch which is somewhat unanchored, with many staff seemingly quite disillusioned.

Nevertheless, there are reasons to be optimistic that the Branch can significantly accelerate its performance. It can draw on exemplars such as the British Antarctic Survey (BAS) which has positioned itself as one of the most important national polar programs. It can draw on the renewed strength of the leadership team following the AAD Director's appointment of several new branch heads in addition to the Chief Scientist. It can draw on the world standard research and the scientists leading it that does exist in the Branch. And it can draw on the Director's statement in several public forums that he wants to ensure that science is at the centre of the Division's activities. This is consistent with other DAWE initiatives to enhance the role of science in the Department that the Secretary of DAWE, Mr Andrew Metcalfe AO, told the Review about. These initiatives include the appointment of a Science Convenor for the Department, and the forthcoming health check by Dr Geoff Garrett AO of the Department's science capability and professionalism.

Acceleration of the Science Branch's performance can only occur by taking into account the context in which it operates. At the national level sits the Australian Antarctic Program (AAP). It comprises the AAD and the work of major Government agencies such as CSIRO, the Bureau of Meteorology (BoM) and Geoscience Australia (GA); major Government-funded research initiatives such as the Australian Antarctic Partnership Program (AAPP), Securing Antarctica's Environmental Future (SAEF, led by Monash University) and the Australian Centre for Excellence in Antarctic Science (ACEAS, led by the University of Tasmania).[1] In addition, there are other researchers in the university system who carry out Antarctic research, including at the Institute for Marine and Antarctic Studies (IMAS, University of Tasmania) which enrols many of the PhD students associated with the AAD and offers adjunct university status to many of the AAD staff, allowing them to co-supervise PhD students. Other university researchers participate as partners in the SAEF and ACEAS, and through competitive grants more broadly in Antarctic research.

The 2019 re-establishment of a peak Antarctic science advisory body – the Australian Antarctic Science Council (the Council), whose executive officer is the AAD Chief Scientist – was an acknowledgement that the Australian Antarctic Program needed better coordination, and followed the 2017 governance review of the program (the Clarke Review). In 2020 the Council developed a high-level Australian Antarctic Science Strategic Plan. However, an implementation of this plan is lacking. The new Chair of the Council, Mr Philip Marcus Clark AO, appointed in April 2021, has asserted that a decadal plan is needed.

To address this, the Review recommends that the Council be charged with developing a Decadal Plan to direct implementation of the Strategic Plan. Its cornerstone should be global excellence in high priority science. It should take into account the SCAR Horizon Scan; other peer national Antarctic program strategic plans; existing and planned capabilities; and include programs to deliver Government science priorities and outcomes that support geopolitical imperatives. The plan must give a clear picture to the nation at large of who does what research and has what responsibilities in East Antarctica and the Southern Ocean while promoting national and international collaboration and synergies throughout the AAP.

[1] SAEF and ACEAS are both Australian Research Council Special Research Initiatives (SRIs).

The Division and, for the science component, the Science Branch should be the engine for developing the Decadal Plan and driving the change it heralds. The Chief Scientist is already the Council's executive officer. In order to maximise collaboration, the Chief Scientist will also need to engage other bodies carrying out Antarctic research in Australia, through an advisory body or, possibly, through adjunct appointments.

Creation of, and commitment to, the Decadal Plan will provide the context for clarifying and solidifying the ongoing role of the Science Branch. The Branch should have a pivotal role in driving the Australian Antarctic Program on both science policy and science delivery. Its science policy roles will include being the principal Antarctic and Southern Ocean adviser to the Australian Government, being the custodian of the long-term monitoring program and the Australian Antarctic data model, and driving national and international Antarctic science collaboration. Its science delivery roles will involve leading a small number of critical programs to support Australian Government priorities and filling critical capability gaps.

The Chief Scientist should also play a major role in enabling more ambitious, multi-disciplinary, 'big data' and 'simulation' science by initiating a new and ongoing 'Integrated Digital East Antarctica' (IDEA) program as a fundamental component of the Australian Antarctic Program (possibly positioned as a SCAR initiative led by Australia). It will extend across the whole of East Antarctica and the surrounding ocean and enable large-scale new science programs minimising the cost of field work by:

- building and maintaining a globally authoritative digital model (or twin) of East Antarctica and the surrounding Southern Ocean
- enabling integrated research that brings together data-intensive, modelling and simulation scenario development and prediction science by all AAP participants.

The Chief Scientist, in collaboration with the Council and the AAPP, SAEF and ACEAS, should also take the initiative in strengthening the Australian Antarctic Program and its science institutional model. Recommended actions include:

- identifying the capabilities (people, technology, science) required for delivery of the Decadal Plan, mapping them against current capabilities, and developing a program to fill the gaps – for Science Branch, this should include high quality secondments in to build its own capability
- developing a program to support the development of Australia's current and future Antarctic science leaders and enable succession planning
- preparing submissions for ongoing science funding following the ending of the AAPP, SAEF and ACEAS programs (in 2029, 2028 and 2025 respectively).

The timing is right for all of these actions to be successfully completed.

The major investment by government in the long-awaited new icebreaker RSV *Nuyina* will catalyse Antarctic and Southern Ocean science opportunities. There is a continuing willingness by the Tasmanian Government and institutions such as the Department of Primary Industries, Parks, Water and the Environment (DPIPWE) and the University of Tasmania (UTas) to support and work with AAD and to share facilities and staff in Tasmania including Macquarie Island.

The Review envisions that implementation of the Decadal Plan will lead to visible impacts in Australian Antarctic science within one year, provided that there is appropriate support and resourcing. Australia's international reputation for Antarctic science will increase within three to five years as Australia transforms knowledge of East Antarctica and its impact on other earth and living systems.

This uplift in the reputation of science within the AAD will also enhance the role of Tasmania as the gateway to East Antarctica. Through increased international collaborations and highly-focused science addressing the 'big challenges', a critical mass of high-quality science expertise and infrastructure will make an increasing contribution to the Tasmanian economy.

All this will be driven by the Australian Antarctic Division and its Science Branch in collaboration with other participants in the Australian Antarctic Program.

List of recommendations

Recommendation 1: Science at the centre of the AAD

That the Division adopt as its core value that science is at the centre of all its activities; and that it further adopt:

- a narrative underpinning its work in accordance with this value
- funding and logistics allocation processes that reinforce this value.

Recommendation 2: Decadal plan to drive science priorities and programs

2.1 That the Australian Antarctic Science Council develop a 10-year Australian Antarctic science plan (Decadal Plan) to implement the Strategic Plan (which should be updated), including:

- programs to deliver the science priorities and outcomes, as per the Strategic Plan
- science programs to support geopolitical priorities, as per Recommendation 2.2
- consideration of the SCAR horizon scans, taking into account that the cornerstone of all major and successful national Antarctic programs is excellence in science in a global sense.

The work of preparing and drafting this Plan will be led by the Chief Scientist who is Executive Officer of the Council. [See Recommendation 6 also.]

2.2 That the Division develop recommendations to Government on the science programs that might best support Australia's geopolitical interests in Antarctica, including those relating to the Antarctic Treaty System. This process may identify science programs that are additional to the Strategic Plan priorities, addressing Australia's physical and virtual presence across the Australian Antarctic Territory.

2.3 That the Division explicitly consider and advise the Council on the opportunity for more cost-efficient, high impact science which enables Australia to demonstrate its presence across a larger component of the Australian Antarctic Territory. This might include, but would not be limited to, the potential benefit and use of remote sensing technology and data coordination and analysis across national and international Antarctic programs. This will include ongoing familiarity with international as well as Australian research being carried out concerning East Antarctica and the data being produced through that research. [See Recommendation 5 also.]

2.4 Within the Decadal Plan, and in consultation with the Council, AAPP and SRIs, that the Science Branch identify the specific critical programs that it will lead, consistent with the recommendations on the role of the Science Branch.

2.5 That reporting against the Decadal Plan be done on an annual basis and that the Plan be updated at least every three years.

Recommendation 3: Role of Science Branch

3.1 That the Science Branch *policy* roles be formalised as:

- principal Antarctic (and Southern Ocean) science adviser to the Australian Government, through the Division, including the synthesis of relevant science undertaken by other Australian and international science bodies
- secretariat to the Australian Antarctic Science Council (the Council)
- manager of the science capability program (refer Recommendation 7)
- custodian of the long-term monitoring program (refer Recommendation 4)
- custodian of the Australian Antarctic data model
- facilitator of Australia's national and international Antarctic science collaboration (refer Recommendation 6).

3.2 That the Science Branch *delivery* roles be formalised as:

- leading [a small number of] critical programs to support Australian Government policy priorities, provided these programs are part of a well-defined challenge science program in the Decadal Plan and satisfy one or more of the following principles:

    - to support the Branch's commissioning, coordination and science policy advisory functions to the Government including for treaty or other international obligations (e.g. fishing limits mandated through CCAMLR)
    - to support the assimilation and synthesis of science and research undertaken by parties outside the Australian Antarctic Division
    - for reasons of national security
    - to minimise human impact on sensitive Antarctic terrestrial and marine ecosystems
    - to support custodianship of the Australian Antarctic data model programs
    - to ensure ecologically sustainable use
- filling any critical capability gaps, or helping partner organisations fill critical capability gaps, in the Australian Antarctic science program, where necessary using a 'secondment-in' model where senior researchers in a particular field work in AAD for a short period
- undertaking long-term monitoring that underpins the Australian Antarctic science priorities and programs
- leveraging the data model and driving the development of a digital twin in support of Australia's science and geopolitical interests, including through a program of data development, access, analysis and publication (this should include a refreshed mapping program over the Australian Antarctic Territory – possibly in collaboration with Geoscience Australia).

3.3 In general, that the Science Branch:

- not deliver sub-scale science programs, or programs not aligned with the needs described under 3.2
- minimise duplication of capabilities and programs across Australian Antarctic science, working with the other relevant Australian agencies and universities to review the range of programs in parallel with the cycle of reviews of Science Branch science delivery
- maximise efficiencies in the use of scientific infrastructure and data for Antarctic and related science.

Recommendation 4: East Antarctic Monitoring Program (EAMP)

That Science Branch, with the support of the Australian Antarctic Data Centre, create, manage and be the custodian of a formal, long-term monitoring program (the East Antarctic Monitoring Program – EAMP), building on and extending monitoring done over decades by AAD and partners and ensuring maximum use of technological developments in data science, low-cost sensors, spaceborne sensors, and autonomous vehicles.

Establishing the EAMP will involve:

- determining the essential physical, biological and chemical variables to be measured, guided by relevance, feasibility and effectiveness
- determining the frequency and duration of measurements and the preferred data collection methods to be used in designing and/or continuing long-term monitoring through wide consultation with end-users
- ensuring the use of intercalibrated, state-of-the-art standardised methodologies for data collection
- implementation of quality assurance/quality control procedures to ensure the integrity and comparability of data over timeframes consistent with natural and human-induced change
- ensuring easy access to data and robust archival storage methods for timeframes that will span decades
- curating all past data collections including forensic investigations to rescue long-term datasets/records and other information in all forms; assessing and documenting the quality and value of archived data; and transferring all data to modern storage and preservation technologies to promote wide access by end-users.

The resulting data will be open access and formally curated, stored and quality controlled for the purposes of understanding long-term change and providing data streams of known quality to predictive systems such as large-scale models and digital twins. This dynamic data collection and appropriate software tools will together constitute the AAT Virtual Observatory, presenting all the monitoring material online in an accessible format, including real-time where possible. The proposed EAMP will work closely with related national bodies such as IMOS, international programs such as the Southern Ocean Observing System (SOOS), and data products curated by SCAR (e.g. BEDMAP3,[2] Biodiversity.aq,[3] the International Iceberg,[4] and the Seismic Data Library System[5]).

Recommendation 5: Integrated Digital East Antarctica (IDEA)

5.1 That the Science Branch initiate and lead a new and ongoing 'Integrated Digital East Antarctica' (IDEA) program as a fundamental component of the Australian Antarctic Program. The IDEA program will integrate and leverage:

- the new AADC and AAPP digital capabilities
- Australia's expertise in other application areas in data science, remote sensing, large robotics, smart sensors, and modelling
- historic and future Australian data from the AAP, including from the AAPP, SRIs, GA, BoM, CSIRO, MNF, IMOS (including its Ships of Opportunity Facility) and the new icebreaker and field platforms
- international data, from SCAR programs and remote sensing platforms
- initiatives including the ACCESS NRI's leadership in simulation such that next generation simulation capabilities inform the development of a digital twin for East Antarctica.

5.2 That the geographic extent of IDEA be the whole of East Antarctica and the surrounding ocean, which fully incorporates the AAT and Australia's Exclusive Economic Zone claim; and its objectives be to:

- build and maintain the globally authoritative digital model (or twin) of East Antarctica with input from at least CSIRO, GA, BoM and the university sector
- enable integrated research programs (building from the data architecture noted above to include modelling, scenarios, and prediction) by all AAP participants.

These objectives have both geopolitical and scientific dimensions. The IDEA will be a modern (digital) expression of Australia's AAT sovereignty claim[6] (our digital footprint on the ice), facilitate collaboration with other national Antarctic programs including through SCAR, and enable more ambitious multi-disciplinary 'big data' science. The IDEA will initiate and enable new science programs, by current and new researchers, without the cost of field work. IDEA could even be positioned as an Australian-led SCAR initiative.

Critical initial steps in developing the IDEA include:

- identify the research questions in the Decadal Plan which can only be addressed by developing the IDEA (this is an iterative process; the Decadal Plan should generate other science and geopolitical use-cases for the IDEA, including in the Antarctic Treaty System)
- review current Australian and international data holdings and monitoring programs against the science and policy user needs, to identify data gaps

[2] https://www.scar.org/science/bedmap3/home/
[3] https://www.biodiversity.aq
[4] https://www.scar.org/resources/iceberg-database/
[5] https://www.scar.org/sdls/
[6] Following the passing of the 1933 Australian Antarctic Territory Act, the Australian Government decided that production of a comprehensive map of Antarctica would assist the consolidation of its territorial claims. The resulting map, published in 1939 (Bayliss and Cumpston, Department of the Interior) was recognised as 'the world's first reliable map of Antarctica'. A digital twin of East Antarctica, incorporating topographic, bathymetric and other spatially-referenced historic and current scientific data, would be the 21st Century equivalent.

- examine and assess existing digital twin initiatives to establish strategies that can be adopted by the Division
- develop programs to fill those gaps (including via international collaboration and remote sensing, where possible).

5.3 That these science and policy-driven applications and programs be led by Science Branch, in collaboration with the AAD's Technology & Innovation and Policy & International Branches. The technical architecture for the IDEA should be developed in consultation with members, noting that several other Commonwealth agencies and universities have significant digital capabilities and experience.

Recommendation 6: Science collaboration

6.1 To maximise collaboration in Australian Antarctic science, that the Chief Scientist convene an advisory group to help her draft the Decadal Plan. Ideally, this group should include the leaders of the AAPP and the SRIs, and appropriate leaders from the other entities carrying out major Antarctic research, CSIRO, BoM and GA, as well as Science Branch itself.

6.2 That the Chief Scientist, with input from the advisory group, develop a collaboration program to deliver the Decadal Plan, including logistics support, data sharing and science symposia.

6.3 That, in developing the Decadal Plan, the Chief Scientist pursue opportunities for Australian leadership and participation in SCAR programs that are aligned with the Plan. In particular, that the focus be on regional and continental data analytics and remote sensing programs that would link to the Australian data model but not require new logistics support. More generally, the Chief Scientist should examine possibilities for maximising collaboration with other polar programs, with a view to increasing science impact significantly and sharing expensive facilities.

6.4 That the Chief Scientist examine and report on the short and long-term research opportunities and collaboration which could be realised and strengthened through co-location of Hobart-based elements of the Australian Antarctic science community as a key element in the broader program of work by the Australian and Tasmanian Governments to develop a business case for the creation of a state-of-the-art Antarctic and Science Precinct at Macquarie Point.

6.5 That the Chief Scientist, in collaboration with the Council, develop a plan for further strengthening the Australian Antarctic science institutional model. This should include consideration of unimplemented recommendations from the Clarke Review and a submission to Government (through the Division and Department) for ongoing science funding following cessation of the AAPP and SRI programs. It should also include processes to second or otherwise engage high quality research groups from other institutions as required.

Recommendation 7: Science capability

7.1 That the Chief Scientist, in collaboration with the Council, AAPP and SRIs, determine the future Australian capabilities (people, technology, science) that will be required to deliver the Decadal Plan, map current capabilities against those needs, and initiate a program to fill any gaps. This process should be repeated every three years.

7.2 That the Chief Scientist develop a program of secondments from other Australian and international science bodies to strengthen Science Branch capabilities in strategic areas. (This program should be based on win-win-win principles – for the Branch, the home institution and for individual career development).

7.3 That a regular review cycle of research programs across the AAP, aligned to the three-year capability review, be encouraged.

7.4 That the Chief Scientist, in collaboration with the Council, AAPP and the SRIs, develop an integrated, cost-effective and best-practice program, with five and 10 year targets,

to support development of future Australian Antarctic science leaders, at all levels (postgraduate, postdoctoral, early-mid career, principal investigator, Future Fellow). This program to include co-supervision, funding and international linkage arrangements.

Recommendation 8: Science infrastructure and logistics support

8.1 That the Decadal Plan be informed by a coordinated overview of available national (and potentially international) science infrastructure and logistics support to ensure the expression of priorities and investment in research is matched by available operational support, particularly on ice.

8.2 That future decisions on the allocation of the available support be made by the Director, AAD, with advice from the Council and the Chief Scientist and other appropriate branch heads, in consultation with the heads of the AAPP and the SRIs, to help mitigate the potential for perceptions of conflict of interest.

Recommendation 9: Communication

That the AAD, informed by the Chief Scientist and the heads of the Policy & International and Strategy & Communications branches, develop an appropriate ongoing Government communication strategy that covers the continuing AAD science/policy nexus, in the context of the proposed AAP Decadal Plan.

Recommendation 10: Leveraging capability in Tasmania

That the Chief Scientist foster a culture of intra-Tasmania cooperation in AAD and look for opportunities for strengthening cooperation with other Tasmanian entities which engage in Antarctic and Southern Ocean research.

Recommendation 11: Getting there from here

11.1 That, under the guidance of the Science Council, the Science Branch move rapidly to do the work needed to develop the Decadal Plan. This will involve:

- developing with the help of Policy & International Branch a sophisticated understanding of how Antarctic and Southern Ocean science can serve Australia's needs and articulating these needs in a clear statement that spells out customer agencies and timeframes and by when these needs have to be met
- auditing what is available already to help deliver on these needs including: current projects carried out by all organisations in the AAP, noting delivery responsibilities and timeframes; international Antarctic science collaborations between Australia and other nations; and data collections (historical and recent; national and international) of aspects of East Antarctica and the surrounding ocean
- identifying the capabilities (people, technology, science) required for delivery of the Decadal Plan, mapping them against current capabilities, and developing a program to fill the gaps – for Science Branch, this should include high quality secondments to build its own capability
- consulting all relevant agencies and research organisations
- drafting the Plan with a view to having full consultation finished and Ministerial sign off by the end of June 2022.

11.2 That new structures needed to implement the policy and delivery roles for Science Branch be implemented quickly, with the aim of being in place by the end of June 2022. Significant support and training will be needed to help staff transit to new roles and take on new responsibilities.

11.3 That Science Branch work with Technology & Innovation Branch to implement the Antarctic Monitoring Program and to scope the Integrated Digital East Antarctic program with a view to having funding support for IDEA by the end of 2022.

1. Review process

The Review was commissioned in September 2021 by Mr Kim Ellis, Director of the Australian Antarctic Division (AAD), one of 42 divisions in the Commonwealth Department of Agriculture, Water and the Environment (DAWE) and one of five divisions in its Water, Climate Adaptation, Natural Disasters and Antarctic Group. The primary purpose of the Review was to understand the quality, relevance and impact of the Division's science in the context of Antarctic science being conducted elsewhere in Australia and the world. It was thought particularly valuable to have a review at this time because of the recent appointment of Professor Nicole Webster as Chief Scientist and head of Science Branch in the Division, as well as a range of other new appointments to several other Division branches. The full terms of reference are at Attachment A.

The Review was conducted by an experienced panel of nine members:

Chair:	Professor Mary O'Kane AC FTSE
Focusing on science strategy:	Mr Drew Clarke AO PSM FTSE
	Mr Greg Johannes
Focusing on science quality:	Mr Martin Exel (stakeholder/fisheries)
	Professor Helene Marsh AO FAA FTSE (conservation/threatened species)
	Professor Andy Pitman AO FAA[7] (climate science)
	Dr Ian Poiner FTSE (marine science/monitoring programs)
	Dr Jenny Stauber FAA FTSE (risk and remediation).
Focusing on international:	Professor Mahlon "Chuck" Kennicutt II

Brief biographies of the panel members are at Attachment B.

The full panel met seven times as a panel. A strategy group of the panel, comprising Professor O'Kane, Mr Clarke, Mr Johannes and Professor Pitman, met separately five times. The Chair met several times with the Director and had frequent discussions with Professor Webster throughout the Review. The Chair and Mr Clarke also spoke directly with the Minister for the Environment, the Hon Sussan Ley MP (in whose portfolio the AAD sits), with the Secretary of DAWE, Mr Andrew Metcalfe, and with the Deputy Secretary in DAWE with responsibility for the Division, Ms Lyn O'Connell.

The Review consulted widely, nationally and internationally. Interviews and panel meetings were held by telephone or video-conference due to COVID-19. At the time of the Review there were lockdowns in NSW and the ACT where some panel members reside, and the Tasmanian border was closed to Victoria, NSW and the ACT.

Most international consultation was conducted by Professor Kennicutt, a former president of the Scientific Committee on Antarctic Research (SCAR), an International Science Council body and the leading international body on Antarctic science. He spoke with several international Antarctic science body leaders with whom he has had a long association.

In Australia, the Review consulted with government (Australian and Tasmanian), industry and research stakeholders, with interviews conducted by various members of the panel.

The Review also spoke with people in other parts of the Division. It interviewed all the AAD branch heads, some individually and some in groups. It spoke several times with the new head of the Policy & International branch, Ms Gaia Puleston, who Mr Ellis has signalled will be working closely with the Chief Scientist on future planning and policy along with Ms Kelly Buchanan, head of the Strategy & Communications branch. It also spoke with Mr Andy Sharman, Environmental Manager in the Assets & Infrastructure branch and Dr Johnathan Kool, who is manager of the AAD's Data Centre within the Technology & Innovation branch

[7] At the panel's first meeting, the Chair invited any member of the panel to participate also in the strategy group, and Professor Pitman did.

and his colleague, Mr Rob Jennings. Dr Kool is also chair of SCAR's Standing Committee on Antarctic Data Management.

Overall, more than 40 interviews were conducted. A complete list of people interviewed is at Attachment C. A short summary of common themes which emerged from the consultations is provided in section 4.

The panel allocated 14 and 15 October for presentations by and interviews with Science Branch staff (see Attachment D for the program). This began with an overview by the three program leaders, and included meetings with each of the 10 teams, the Cross-Program Projects team, and the Branch's Manager, Science Planning and Coordination, Ms Rhonda Bartley. The panel also met with DAWE's Science Convenor, Dr Dirk Welsford (a former AAD Science Branch Acting Chief Scientist), and six early career researchers who are connected with AAD. In addition, seven teams and one program leader provided additional written material in response to questions posed by the panel.

Most of the panel also attended (by video link), or watched later, the AAD Science Symposium held on 29 September, at which staff from across the Division came together to share their science results.

AAD has commissioned a quantitative analysis of Science Branch's research quality and, to some extent, impact from Clarivate. At the time this Review was completed only preliminary data analysis was available from Clarivate. Their preliminary results are consistent with the Review's findings.

2. Context

Sovereignty

Australia asserts sovereignty over 42% of the Antarctic continent, in the region known as East Antarctica, a claim of strategic importance. This assertion, and related maritime claims, is maintained by Australia's occupation of the Australian Antarctic Territory (AAT), by its conduct of science to monitor, understand and predict the behaviour of East Antarctica, and by its active participation in the international Antarctic Treaty System. It was often said to the Review that 'science is the currency of Antarctica' which reflects Articles II and III of the Treaty.

There are pressing needs for a greater scientific understanding of East Antarctica and the Southern Ocean, because of the unique influence the region has on the global climate system and the ability to understand and predict changes to the climate, the environment and sea level rise. Two examples of current scientific issues are the contribution of ice loss to climate change, and the impact of climate change on krill stocks as the keystone species in the ecosystem and consequential changes in the food chain. There are also pressing geostrategic issues, including the increasing interest in expanding fishing near East Antarctica.

At the moment Australia's presence in and knowledge of the claim area is limited, being concentrated around the three science stations, Davis, Mawson and Casey. In fact, the Review noted that, while Australia claims sovereignty over the entire AAT, much of that area has had little or no scientific activity for many years, potentially undermining (or at least failing to support) those claims. The AAP does not currently include a program to publish up-to-date maps of the AAT, which is a recognised component of any nation's territorial claims.

Antarctic Treaty System

Australia was one of the original 12 signatories to the Antarctic Treaty System, which came into effect in 1961; an additional 42 member states have also acceded to it. The Treaty specifies that Antarctica is to be used only for peaceful purposes and the continuation of scientific research. The system was augmented by the 1991 Protocol on Environmental Protection to the Antarctic Treaty (the Madrid Protocol) and the 1982 Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR).

Australian Antarctic Division

While the Department of Foreign Affairs and Trade (DFAT) is responsible for Australia's compliance with its Treaty obligations, and negotiation and monitoring in respect of the legal and geopolitical elements of Australia's claim, Australia's active involvement in the AAT is managed by DAWE through the AAD. AAD is responsible for leading, coordinating and delivering the Australian Antarctic Program and administering the Australian Antarctic Territory and, in the subantarctic, the Territory of Heard Island and McDonald Islands, a World Heritage site. [Macquarie Island, another World Heritage site, which is formally a part of Tasmania, is not administered by the AAD, but the Division has facilities on the island.]

The AAD coordinates the logistics and operational aspects of most Australian travel to and presence in the AAT, i.e. for scientific expeditions and activities across the whole Australian Antarctic Program, not just that of the AAD and its Science Branch. This is the role for which it is best known. In recent years the Australian Government has made a significant commitment to the upgrading of key Antarctic infrastructure, including the commissioning of a new icebreaker, RSV *Nuyina*, which arrived in Hobart in October 2021. This vessel is intended to provide a significant capability boost to Australia's science activities. A consequence of this logistics role is that the proportion of the total AAD operational budget (excluding capital costs) spent on actually doing science in the Science Branch is about 7% (about $15m a year).

It is not surprising that many people see AAD's focus as being primarily logistics, and not science. Of the six branches in AAD, three relate to the capabilities side, namely Assets & Infrastructure, Technology & Innovation, and Operations & Safety. The two other branches are Policy & International and Strategy & Communications. Science Branch has 68 FTE staff, about 15% of the total FTE in the Division.

The current Director of the AAD, Mr Kim Ellis, took up the role in February 2019, and has been undertaking a leadership renewal process within the Division. The Division's Chief Scientist, Professor Nicole Webster, and the head of Policy & International were appointed in 2021, and the heads of Technology & Innovation and Strategy & Communications were appointed in 2020. Mr Ellis informed the Review that the Division has been missing a 3 to 5-year cycle of science reviews to ensure that it does excellent science that addresses high priority questions for Australia and the globe while supporting Government policy; and it is now timely to begin this process.

Australian Antarctic Program

As stated in the *Australian Antarctic Strategy and 20 Year Action Plan* (Commonwealth of Australia, 2016), the most recent major Government statement on Antarctica, the Australian Antarctic Program (AAP) is focused on "conducting world-class science of critical national importance and global significance that delivers on Australian Antarctic policy and operational priorities".

While this Review is primarily focused on the science in AAD's Science Branch, it is impossible to consider that work without taking into account the wider context of the science carried out in the AAP. The Review was unable to find a precise definition of the AAP,[8] but the term is generally used to cover all Australian Government activities in Antarctica, plus Commonwealth-funded entities, generally hosted in universities, carrying out Antarctic research. Thus, the AAP is wider than AAD alone and the science of AAP is wider than in AAD's Science Branch.

[8] The Review noted that an internet search for "Australian Antarctic Program" brings up a site primarily dedicated to the AAD, although references to other parts of the program such as the Australian Antarctic Science Council can also be found there.

There are four Commonwealth-funded entities[9] whose primary focus is on Antarctic science and research to support the Australian Antarctic Program, although three are funded for a limited term. These are:

- AAD's Science Branch – recurrent funding of about $15m a year
- the Australian Antarctic Program Partnership (AAPP), a partnership of Australia's leading Antarctic research institutions, supported by the Australian Government Antarctic Science Collaboration Initiative and administered by the Department of Industry, Innovation and Science – $50m over 10 years concluding in 2029
- Securing Antarctica's Environmental Future (SAEF) led by Monash University, funded under the Australian Research Council Special Research Initiative for Excellence in Antarctic Science, involving 25 research partners and collaborating universities – $36m over 7 years concluding in 2028
- Australian Centre for Excellence in Antarctic Science (ACEAS) led by UTas, also funded under the Australian Research Council Special Research Initiative for Excellence in Antarctic Science, involving 41 research partners and universities – $20m over 3 years concluding in 2025.

Another body with a strong Antarctic research mission is the Institute for Marine and Antarctic Studies (IMAS) at UTas. Many other universities also engage in Antarctic research either through the Special Research Initiatives and/or the AAPP or through the wider national competitive research grants process, which includes the Australian Research Council (ARC), the Fisheries Research Development Corporation (FRDC) and the National Environmental Science Program (NESP).

Other Government agencies which contribute to the Australian Antarctic Program include CSIRO, BoM and GA.

Clarke Review

In 2017 Mr Drew Clarke (also a member of this Review panel) completed a Governance Review of the Australian Antarctic Program, and made nine recommendations around structure, strategy and administration. These included the establishment of the Australian Antarctic Science Council (which has been implemented – see below), the establishment of an Australian National Antarctic Research Institute (which has not been implemented), and the development of a comprehensive data model of the Australian Antarctic Territory (which has been partially implemented). Mr Clarke's report, the Commonwealth Government's Response to the report, and the feedback received from many stakeholders about the value of the Clarke report, have informed this Review and influenced its recommendations.

Australian Antarctic Science Council

Since 2019, and as a consequence of the Clarke Review, the provision of strategic advice to the Government on the science component of the Australian Antarctic Program has been formally provided by the Australian Antarctic Science Council (the Council). It "advises Government on the program, including Antarctic science priorities"[10] in the context of the *Australian Antarctic Strategy and 20 Year Action Plan*. The Council has an independent chair and two independent members who are appointed by the relevant Minister, and seven ex officio members: CSIRO, BoM, GA, the ARC, the Department of Industry, Science, Energy and Resources, the AAD and the Australian National Committee for Antarctic Research (NCAR – a committee supported by the Australian Academy of Science). The AAD's Chief Scientist is the Executive Officer of the Council, which meets formally four times a year.

In April 2020 the Council released the Australian Antarctic Science Strategic Plan (AASSP), a one-page outline of key themes and principles for Antarctic scientific research. The themes

[9] These organisations also receive support (cash and in-kind) from the partner bodies in them.
[10] https://www.antarctica.gov.au/science/australian-antarctic-science-strategic-plan/australian-antarctic-science-council/

and principles in the plan are set at a very high level, and there is no implementation plan, so its use as a strategic planning document is of limited value at present, and meant the Review could make no judgements on how well the Science Branch was delivering against either this plan or the *Australian Antarctic Strategy and 20 Year Action Plan*.

A new chair, Mr Philip Marcus Clark AO, was appointed to the Council in April 2021. He told the 29 September 2021 AAD Symposium that he is a strong supporter of the Clarke Review recommendations. The Head of the Division, Mr Kim Ellis, has recently engaged the Nous Group to "review the Council's Purpose and Terms of Reference and to develop a strategy for the Council to give effect to the Government's Australian Antarctic Science Strategic Plan". Mr Clark told the Review he strongly recommends a decadal plan to help with implementation of the AASSP.

Science bodies

The most important and influential international body is the Scientific Committee on Antarctic Research (SCAR), an International Science Council thematic body. SCAR is charged with initiating, developing and coordinating high quality international scientific research in the Antarctic region (including the Southern Ocean) and research on the role of the Antarctic region in the Earth system. SCAR also provides objective and independent scientific advice to the Antarctic Treaty Consultative Meetings and other bodies such as the United Nations Framework Convention on Climate Change (UNFCCC) and Intergovernmental Panel on Climate Change (IPCC) on issues of science and conservation affecting the management of Antarctica and the Southern Ocean and on the role of the Antarctic region in the Earth system. The chair of NCAR, Professor Nerilie Abram (who is also on the Council), is Australia's Delegate to SCAR, with the AAD Chief Scientist the Alternate Delegate.

The NCAR, one of 22 national committees supported by the Australian Academy of Science, "aims to foster Antarctic science in Australia and serve as an effective link between Australian and overseas scientists working on Antarctic issues". Its role includes liaison with SCAR and supporting active Australian involvement in SCAR international programs. The scope of research covered by NCAR "reflects that identified in the Australian Antarctic Science Plan".[11]

Important international bodies connected with the Antarctic Treaty System include the Council of Managers of National Antarctic Programs (COMNAP) and the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR).

3. Consultation themes

In the extensive external interviewing process, a number of key themes emerged, although many are related. These included:

- the limited visibility of AAD-led science in driving the agenda at world forums such as SCAR
- the patchy quality of AAD science (though there are some real strengths), and the breadth of science at the apparent expense of depth
- the lack of clarity around Science Branch's role in the Australian Antarctic Program, what science the AAD (as opposed to other parties) should do, and why it does what it does
- the opaqueness of the process of allocation of logistics support to Antarctic science projects across the sector
- the opportunities for using technology such as data science, modelling, remote sensing including satellite imaging, and autonomous vehicles to conduct large-scale science in a cost-efficient way that also expands Australia's territorial presence
- limited collaboration with other agencies to deliver science excellence
- the lack of succession planning and staff training and development for Antarctic science.

[11] https://www.science.org.au/supporting-science/national-committees-science/national-committee-antarctic-research

In light of its interactions with internal AAD staff, the Review panel (which has wide experience in reviews of this kind) noted that:

- although Science Branch staff appeared passionate about their work, many displayed a glumness about their environment, largely due to their declining resources and capacity over the last two decades, and were lacking enthusiasm for the future – for example, there was remarkably little excitement expressed about the potential offered by the arrival of RSV *Nuyina*
- many (not all) Science Branch staff were unable to explain how their science activities fit into the Australian Antarctic Program as a whole or how they address key Government policy issues, except where their activities were linked to CCAMLR or the International Whaling Commission (IWC). Their connections with SCAR (or lack of them) were also not raised, though some attributed lack of participation to restrictions on travel to international meetings.[12]

4. Quality, relevance and impact of science

Quality and impact

The Review's overall assessment of the quality and impact of Science Branch's output is that it is mixed: some is high quality research with high impact; some is good science directed to end-user needs; some is good individual science or science done by groups which lack the critical mass needed to tackle large-scale complex questions; some is not in itself of high quality but may lead to promising opportunities; some provides fundamental capacity or capability building; some has high quality aspects but is not well connected to related major initiatives; and some is of marginal quality.

The Review also noted that much of the Branch's science could not be regarded as addressing the high priority or large-scale, complex scientific questions best answered by research in Antarctica, such as those identified by the SCAR Antarctic and Southern Ocean Science Horizon Scan 2014,[13] which were agreed by consensus of leading Antarctic scientists, policy makers and science delivery representatives following an extensive process led by an International Steering Committee chaired by Professor Kennicutt, and updated in 2019.[14]

The three areas that could be described as being 'at world standard' or above (used in the sense that the ARC uses for Excellence in Research in Australia, the national research evaluation framework) are sea ice, ice cores and ice sheets – with the qualification that this work is dependent on the expertise and efforts of individual scientists or small teams and a lot of the science is dependent on external partners enabling the work.

a. The **Sea Ice** team has made a significant contribution to the UN's IPCC science, and critically to national modelling infrastructure via the Consortium for Ocean-Sea Ice Modelling in Australia (COSIMA), and to several significant policy briefs. While the team has few first-author peer-reviewed publications, this group is a large fraction of the national effort around Antarctic sea ice modelling and its integration into ACCESS.[15]

   Antarctic sea ice is important to Southern Ocean weather and climate, and to climate projections through ACCESS. The national program in sea ice modelling, however, needs review. As the AAD program has become smaller, the BoM has become more active, and the SRIs and AAPP have significant common interests. There is an opportunity for the AAD to initiate and lead the national strategy around sea ice to

[12] The Division has pointed out to the Review that there was a high frequency of staff travel to international science meetings up to the arrival of COVID-19.
[13] https://www.scar.org/science/horizon-scan/overview/
[14] https://doi.org/10.1016/j.oneear.2019.08.014
[15] ACCESS (Australian Community Climate and Earth-System Simulator) is a physics-based forecast modelling system, developed by BoM, the CSIRO and Australian universities in consultation with international partners.

ensure its role is fully recognised and other actors' investments are aligned in a coordinated program. But the Review found the AAD sea ice team is not sustainable at its current staffing level.

b. The **Ice Core** team has been fundamental to a vast array of impactful research by providing the leadership and capability to collect and analyse ice cores. Policy briefs from the AAD regularly scaffold from these cores and the resulting science. A great deal of highly significant science has resulted from this that would not have otherwise been possible. It would be unworkable to have an active ice core program without a wrap of highly capable scientists. The team is the fundamental national capability for ice coring and the provision of ice core sampling, and provides the foundation for research conducted by many groups nationally and internationally.

c. The **Ice Sheets** component of the Atmosphere and Ice Sheets team has a single oceanographer/glaciologist who is well established in Australian ice sheet science with strong links to AAPP and an SRI. But just one FTE is inconsistent with the importance of ice sheet (and sea level) science and the need for long-term coordination of this research area by a government entity, although an excellent group could be built around this scientist's expertise and leadership.

The Review noted that some good science productively focuses on end-user needs. Examples include:

- the **Fisheries Ecology & Management** team's work, which has been scoped and led by international requirements at CCAMLR, along with national priorities established in conjunction with the Australian Fisheries Management Authority (AFMA) and the Fisheries Research & Development Corporation (FRDC). This work is done in conjunction with IMAS at UTas, which has employed several Fisheries scientists from AAD on permanent contracts to help with a staffing cap in AAD (a good example of collaboration between Antarctic science bodies). The work is important because it helps ensure that CCAMLR-mandated catch limits for Southern Ocean fishing are evidence-based, and reinforces that ecosystem-based fisheries management is a key priority for Australian Antarctic territories

- the **Remediation** team's work, which is largely funded by the insurance industry (so staffing contracts are all limited term), and supported by the **Environmental Toxicology** team**,** is mainly focused on diesel pollution and contaminant clean-up. This is solid science-based remediation work targeted towards reducing the human footprint in East Antarctica and supporting Treaty requirements. While it is not world-leading research and not connected to leading edge science in Antarctic remediation done by other countries, it is developing new environmental assessment tools and delivering good restoration outcomes, with some of the techniques being used by other countries such as Brazil and Argentina. This research could benefit from the development of an overarching conceptual model and risk framework to support research and restoration priorities. The Review noted that remediation is a problem common across all countries with an Antarctic presence but there seems to be limited connection between Australia's work and the work of other countries.

An example of work which shows promise is krill. The **Southern Ocean Ecosystems & Monitoring** team has shown considerable innovation in successfully getting wild Antarctic krill to school and reproduce in its aquarium as they do in the wild. As their website states, this "allows their early life stage to be studied in detail, which is key to understanding their survival through the harsh Antarctic winter conditions, and consequently providing a greater understanding of how krill contribute to the Southern Ocean ecosystem". While the aquarium breeding itself is good science, the major outcome is the potential for further studies of krill, which is a foundation of the Southern Ocean food chain, into a major program to answer high priority interdisciplinary scientific questions. An exciting large-scale project could be proposed that builds on this new access to krill to develop eco-biological models of food

webs in the Southern Ocean. Given the plans to build a major krill aquarium at the IMAS facilities on the UTas Taroona Campus, combined with technological innovations like the krill observational moorings (KOMBIs) to understand krill behaviour under the ice, an interdisciplinary research program focused on critical ecological questions is possible.

An example of work that has some high quality aspects but is not yet well enough connected to related major initiatives is the **atmosphere** component of the Atmosphere and Ice Sheets team. It has demonstrated some good science with contributions to atmospheric chemistry, atmospheric dynamics and other areas including measurements. This group has some evidence of potential succession planning in place. Some of the work, including properties of Southern Ocean clouds, addresses an important bias in climate models with potential for reducing uncertainties in climate projections over Australia. However, the atmospheric program lacks connectivity to national strategies, and seems to have limited understanding of initiatives around ACCESS and in particular the ACCESS-NRI. The pathway for observations, or process-based understanding, into the relevant national strategies is lacking and is, in some cases, duplicative of work long-established within the BoM.

A lot of science work has also been directed at addressing specific issues raised by CCAMLR, and the **Coastal Marine Ecology** and **Wildlife Ecology & Management** teams have been active in research on whales and seabirds. The Review noted that little is being done on pinnipeds except in partnership with a group at UTas.

A recurrent issue is that many research teams are below critical mass (personnel) and therefore too small to have a major impact or influence on the global Antarctic research agenda. Declining investment into the Science Branch over several years in several fields, as well as a staffing cap, has led to staff frustration around the lack of resources and capacity.

Science relevance

Many of the scientists who met with the panel on the 14-15 October interview days struggled to provide a clear reason for why they do the research they do. While many indicated that their research supported the Australian Antarctic Science Strategic Plan (which, as stated above, is broad), or that it was needed for work related to the Treaty, such as CCAMLR, there did not seem to be strong or clear motivations for much of the research conducted.

Lack of relevance has arguably contributed to low science quality and impact in some areas. Not knowing where their work fits institutionally leads to low motivation. Several of those interviewed said that when scientists retire or leave, their research field is dropped and their data is not valued or preserved. This represents a lost opportunity to maximise science impact and value.

It is clear to the Review that Science Branch needs a clear view of its niche in Antarctic research, and it needs planning and active, focused leadership.

Findings

Overall science quality in Science Branch is mixed.

Most branch scientists appear to have only a general idea of why they, and the branch, are doing the science they do. There is no clear strategy behind the branch's science, there is no clear planning process to inform or articulate future strategies, and there is little in the way of staff development. No one seems to own the agenda. The sense was that, once a person with particular expertise left the Division, the expertise left as well, and the science area was subsequently deprioritised without an underlying long-term strategy.

The lack of clarity and prioritisation of what science should be done in the AAD Science Branch is one reason why science quality in the Science Branch is not as high as it could and should be. This lack directly links back to the ill-defined purpose of Science Branch vis-à-vis the other players in the system, namely AAPP, the SRIs, other Government agencies such as BoM, GA and CSIRO, and universities. This, in turn, directly links back to the lack of

an implementation strategy for the Australian Antarctic Science Plan. And fundamentally, it points to a failure of leadership within the system.

5. Building an enhanced future for Australian Antarctic science

5.1 The need for a plan

The Australian Government has the strategic imperative to maintain its claim to the Australian Antarctic Territory through physical presence and the conduct of science in the territory. The Government is the primary funder of Antarctic research and the logistics and facilities required to conduct the research. It is timely to ensure that government priorities for Antarctic science are clearly articulated, and that the governance framework for delivery of this science on a whole-of-government basis is in place. The point was made to the Review that, for a science/policy nexus to work, clarity is required.

Detailed planning and coordination across the AAP are clearly fundamental to Australia ensuring a coherent, effective and high-impact Antarctic science program. The planning needs to be focused, with firm decisions made on what science will best serve Australia's needs and what is second order. This in turn requires a sophisticated understanding of how Antarctic and Southern Ocean science serves Australia's national interest (i.e. spelling out the science/policy nexus). For example, Australia needs to have a richer understanding of the climate change impacts from the South Pole to the tropics. Deeper knowledge of the circumpolar current and changes in sea ice, glaciers and the behaviours and dynamics of animals in the Antarctic and Southern Ocean is vital to this, and vital to maintaining healthy Antarctic ecosystems, ensuring ecologically sustainable use, including through ecosystem-based management of the southern fisheries. Another example – Australia has deep knowledge of only a fraction of its Antarctic claim. Recent advances in data science, autonomous vehicles, sensors and big robotics – combined with long-term satellite, plane and certain terrestrial and marine data – mean that Australia could build a digital twin of East Antarctica, including its oceanic component. This would allow highly productive research across all Australia's claim, research that is relatively low cost, high impact and high coverage compared to on-ground Antarctic research. A digital Antarctica would also allow for systematic probing and identification of critical data and information gaps and how future research programs are to be designed to address these deficiencies. The reduction in uncertainties in climate predictions is an example of focused research efforts that would be illuminated by a digital twin.

As noted several times, AAD is part of a wider system, the AAP. Planning needs to cover and provide for coordination across the whole AAP. The appropriate body to drive this is the Australian Antarctic Science Council. The Chief Scientist, who is the Council's Executive Officer, should develop and drive delivery of an appropriately detailed Decadal Plan fleshing out the issues raised in a refreshed Australian Antarctic Science Plan. This plan should have a strong focus on high impact, excellent research, including the foundational requirements of data and the ultimate goals of prediction. Excellent science derived from research conducted in Antarctica reaches far beyond the Southern Ocean, as is evident in the ongoing climate discussions. Recommendation 2 addresses this issue.

It is important that all components of the AAP and major Antarctic science bodies have strong ownership of the Decadal Plan and its outcomes. The Chief Scientist should draw on appropriate advice in developing and delivering on the plan. This could be done by appointing adjunct deputy chief scientists from the AAPP and the 2 SRIs (moving towards the concept proposed in the Clarke Review of an Australian National Antarctic Research Institute (ANARI)); or it could be by putting together an advisory group comprising the leaders of the AAPP and the SRIs, and appropriate leaders from other endeavours carrying out major Antarctic research (CSIRO, BoM and GA) as well as Science Branch itself. Recommendation 6 addresses this issue.

In establishing a higher impact future for Australian Antarctic science, the Division – and Science Branch in particular – needs a strong narrative that both underpins the Science Council's Decadal Plan and embodies the proposed core value of the Division, namely that *Science is at the centre*. The Review suggests that this narrative should be *Building comprehensive knowledge of East Antarctica and its ecosystems to inform our Antarctic stewardship and enhance our understanding of climate change*, thus moving from a program focussed primarily on work that can be done near the three Australian Antarctic stations to one which builds up strong familiarity with Australia's claim as a whole, including the ocean component. Recommendation 1 addresses this.

A critical component of modern Earth System science is long-term, sustained observations of key environmental variables from the physical to the living world. The AAD, as a government agency, is uniquely positioned to identify, implement, and manage critical networks of sensors and repeat measurements that allow for the detection of long-term trends in essential environmental variables and begin to establish cause and effect relationships that lead to science-based policy decisions to constrain future risk of undesirable outcomes. Recommendation 4 addresses this issue.

Given Australia's expertise in remote sensing and observing systems, its world-leading position in large robotics, its success in big data projects, and the significant amount of data (some Australian; some gathered by other nations) that exists about aspects of East Antarctica, work with complex models and digital twins is a viable way forward. Recommendation 5 outlines an Integrated Digital East Antarctica system.

The decadal plan will need to include planning for when funding runs out for the two SRIs and the AAPP (in 2025, 2028 and 2029) and for the challenge science proposals that will take their place, drawing on the wider Antarctic science capability that exists in the universities, CSIRO and other Government agencies.

The plan will need to be reviewed and updated regularly, say every three years.

5.2 Science Branch can transform

Getting from the current less than optimal situation of science in the AAD to a position where Australia is seen as a high impact player in polar science with a comprehensive program based on East Antarctica is daunting, but there are several factors that suggest that such a transformation is possible. These include:

- the AAD Director's determination to put science at the centre of the AAD's and AAP's work programs (see Recommendation 1) and to have the heads of the Science, Policy & International and Strategy & Communications branches in the Division drive this
- the delivery of the new icebreaker RSV *Nuyina*, with the consequential enhancement of capabilities for Antarctic research
- the new appointments in AAD – the (relatively) new Director, new Chief Scientist, and new heads of Policy & International, Technology & Innovation and Strategy & Communications branches
- the several excellent scientists and the high-impact research areas that are already present in Science Branch
- the quality of the wider Australian Antarctic science partners as seen in other components of the AAP
- a historically strong and growing culture of collaboration across the constituent institutions and funded initiatives that contribute to the AAP
- Australia's (and the world's) increasing imperative to understand climate change and its impacts
- current geopolitical and geostrategic challenges associated with other countries' presence in Antarctica and the Southern Ocean
- the technological possibilities of high-impact, relatively low-cost science offered through advances in data science and observing systems and remote sensing technologies.

The AAD can learn from the stellar example of British Antarctic Survey (BAS) and its current configuration and mission. BAS is world renowned for its high impact research and its leadership in international Antarctic science and policy advice. Because it has a very clear idea of its mandate, negotiated in detail with the government and focussed on British government needs, it is able to engage other organisations, notably universities and other polar programs, in effective science collaboration. AAD and its Science Branch can learn much from BAS.

Recommendation 3 covers the future role of the Branch. Recommendation 11 covers important aspects of getting Science Branch from its current situation to a high-performing role at the centre of the AAD's and the AAP's activities.

Like BAS, the AAD through Science Branch will need to have a full picture of the global sweep of Antarctic science and revise its vision in response to the latest developments and advancements. It needs to be good at commissioning quality science from other bodies and at leading and fostering collaboration nationally and internationally, not only between scientists working on polar matters but also with scientists in fields that need to be drawn on for new technologies. It needs to ensure Australian science not only makes major contributions to SCAR and various Treaty bodies but also drives the agendas in these forums. Recommendation 6 addresses collaboration. Recommendation 9 addresses the related issue of communication. Recommendation 8 addresses making effective use of the expensive infrastructure needed for Antarctic science.

Antarctic research is an attractive option for early career researchers. This interest needs to be nurtured so Australia has a well-trained workforce in appropriate fields for the future. This training requires close linking with the university sector for PhD education. For example, AAD can build on its already strong links with UTas, through IMAS, to support PhD students, with Division staff having adjunct status so they can co-supervise students. Recommendation 7 addresses building the workforce of the future.

An important current feature of Antarctic science that should be retained and strengthened is the cooperation in respect of research, facilities and education between the AAD, Tasmanian institutions (DPIPWE, UTas), and other research organisations with a presence in Hobart (CSIRO, ACEAS, and the Integrated Marine Observing System (IMOS)). Recommendation 10 addresses the opportunities to leverage capability in Tasmania.

In total the Review makes 11 recommendations for change. These are provided in detail below along with the findings that led to them. A description of how the Australian Antarctic Program might look if the recommendations are implemented is also provided.

6. Findings and recommendations

The following sections cover the findings and the recommendations of the Review.

6.1 Science at the centre of the AAD

The Review heard from many stakeholders that the support for actual science within AAD was often perceived to rank second to the logistics, safety and infrastructure challenges of accessing and operating in the harsh environment of Antarctica. In contrast to this perception, the Review heard the AAD Director declare, both to the Review and in wider forums, that science should be at the centre of all AAD's activities. The Secretary of DAWE, Mr Andrew Metcalfe, echoed this view.

Findings

Adopting a formal value that science is the AAD's central purpose would reinforce the Director's message and send a Division (and national and international) signal that science is the driver of AAD's activities. This value could then be used as the basis for a narrative, a galvanising statement of purpose, to foster a shared culture within AAD and, ultimately, the AAP, with everyone working towards a common aim. The Review suggests that an appropriate narrative would be *Building comprehensive knowledge of East Antarctica and its*

ecosystems to inform our Antarctic stewardship and enhance our understanding of climate change. The value and the narrative together would provide a basis for reconsidering the appropriate funding for the Science Branch; would help ensure that the logistics and operational planning served the science; and would promote clarity for Science Branch on what it needs in the way of logistics support. They would also encourage the Division to focus on 'big' science that is, and is seen nationally and internationally to be, important to Australia.

Goal

To ensure that excellent science drives AAD's purpose and culture so that science underpins all decisions with a view to serving Australia's interests in respect of the Antarctic Treaty, of which it is widely stated that 'science is the currency'.

Recommendation 1: Science at the centre of the AAD

That the Division adopt as its core value that science is at the centre of all its activities; and that it further adopt:

- a narrative underpinning its work in accordance with this value
- funding and logistics allocation processes that reinforce this value.

Expected Outcomes

That Australia is seen as a high impact, consistent player within international forums and, in Australia, that Antarctic science is one of the top fields of science research and impact.

6.2 Decadal plan to drive science priorities and programs

The recommendation in this section defines the development of the planning framework of priorities and programs within which Science Branch will fulfil its policy and delivery roles (as well as defining the roles of other contributors to the AAP). Implementing this framework should accelerate and benefit the whole of Australia's Antarctic science effort.

Findings

The Australian Antarctic Science Strategic Plan, produced by the Council, provides the starting point for clarifying the AAD's research focus. However, it is not possible to identify the specific priorities and programs to be delivered by Science Branch without further development of this Plan. The Branch itself, as Secretariat to the Council, will have a key role in this process.

Goal

A concise and forward-leaning decadal implementation plan for Australian Antarctic science with explicit milestones and a timeline that addresses the highest priority scientific questions in support of national aspirations for Antarctica and the Southern Ocean.

Recommendation 2: Decadal plan to drive science priorities and programs

2.1 That the AAD propose to the Australian Antarctic Science Council that the Council develop a 10-year Australian Antarctic science plan (Decadal Plan) to implement the Strategic Plan (which should be updated), including:

- programs to deliver the science priorities and outcomes, as per the Strategic Plan
- science programs to support geopolitical priorities, as per Recommendation 2.2
- consideration of the SCAR horizon scans, taking into account that the cornerstone of all major and successful national Antarctic programs is excellence in science in a global sense.

The work of preparing and drafting this Plan will be led by the Chief Scientist who is Executive Officer of the Council. [See Recommendation 6 also.]

2.2 That the Division develop recommendations to Government on the science programs that might best support Australia's geopolitical interests in Antarctica, including those relating to the Antarctic Treaty System. This process may identify science programs that are additional to the Strategic Plan priorities, addressing Australia's physical and virtual presence across the Australian Antarctic Territory.

2.3 That the Division explicitly consider and advise the Council on the opportunity for more cost-efficient, high impact science which enables Australia to demonstrate its presence across a larger component of the Australian Antarctic Territory. This might include, but would not be limited to, the potential benefit and use of remote sensing technology and data coordination and analysis across national and international Antarctic programs. This will include ongoing familiarity with international as well as Australian research being carried out concerning East Antarctica and the data being produced through that research. [See Recommendation 5 also.]

2.4 Within the Decadal Plan, and in consultation with the Council, AAPP and SRIs, that the Science Branch identify the specific critical programs that it will lead, consistent with the recommendations on the role of the Science Branch.

2.5 That reporting against the Decadal Plan be done on an annual basis and that the Plan be updated at least every three years.

Expected Outcomes

An Australian Antarctic science roadmap to include a limited number of agreed high priority science focus areas coupled with explicit resourcing (human, logistics, infrastructure, and financial) investments to assemble a critical mass of expertise and capabilities to ensure success.

6.3 Role of Science Branch

The Decadal Plan is intended to clarify Australia's Antarctic science priorities, and ensure they are addressed in a coordinated way by the many actors in this space. The future role of the AAD Science Branch must be aligned with this plan.

Findings

Science Branch has an essential role in the Australian Antarctic Program. In future it should lead the Program, coordinating the work of the Program's constituent research bodies, commissioning research to deliver the Decadal Plan, and providing science policy advice to Government to support Australia's national interests in Antarctica and the Southern Ocean (which includes the World Heritage listed Heard and McDonald Islands and Macquarie Island). The Branch's science role should be more focused than it is at present.

Goal

To define clearly the role of the Branch in the context of both the Division and the overall Australian Antarctic Science Program.

Recommendation 3: Role of Science Branch

3.1 That the Science Branch *policy* roles be formalised as:

- principal Antarctic (and Southern Ocean) science adviser to the Australian Government, through the Division, including the synthesis of relevant science undertaken by other Australian and international science bodies
- secretariat to the Australian Antarctic Science Council (the Council)
- manager of the science capability program (refer Recommendation 7)
- custodian of the long-term monitoring program (refer Recommendation 4)
- custodian of the Australian Antarctic data model
- facilitator of Australia's national and international Antarctic science collaboration (refer Recommendation 6).

3.2 That the Science Branch *delivery* roles be formalised as:

- leading [a small number of] critical programs to support Australian Government policy priorities, provided these programs are part of a well-defined challenge science program in the Decadal Plan and satisfy one or more of the following principles:

    - to support the Branch's commissioning, coordination and science policy advisory functions to the Government including for treaty or other international obligations (e.g. fishing limits mandated through CCAMLR)
    - to support the assimilation and synthesis of science and research undertaken by parties outside the Australian Antarctic Division
    - for reasons of national security
    - to minimise human impact on sensitive Antarctic terrestrial and marine ecosystems
    - to support custodianship of the Australian Antarctic data model programs
    - to ensure ecologically sustainable use
- filling any critical capability gaps, or helping partner organisations fill critical capability gaps, in the Australian Antarctic science program, where necessary using a 'secondment-in' model where senior researchers in a particular field work in AAD for a short period
- undertaking long-term monitoring that underpins the Australian Antarctic science priorities and programs
- leveraging the data model and driving the development of a digital twin in support of Australia's science and geopolitical interests, including through a program of data development, access, analysis and publication (this should include a refreshed mapping program over the Australian Antarctic Territory – possibly in collaboration with Geoscience Australia).

3.3 In general, that the Science Branch:

- not deliver sub-scale science programs, or programs not aligned with the needs described under 3.2
- minimise duplication of capabilities and programs across Australian Antarctic science, working with the other relevant Australian agencies and universities to review the range of programs in parallel with the cycle of reviews of Science Branch science delivery
- maximise efficiencies in the use of scientific infrastructure and data for Antarctic and related science.

Expected Outcomes

AAD Science Branch assumes the principal role of science adviser to the Australian Government, becomes the dominant voice on Australian Antarctic science, houses data streams and the Australian Antarctic data model, leads assessments of critical capability gaps (to include plans to fill gaps), and maximises efficient utilisation of infrastructure and data streams.

6.4 East Antarctic Monitoring Program (EAMP)

The foundations of 21st century Antarctic science are long-term observations of Earth and living systems' attributes. From the discovery of the ozone hole in the1980s, to our current understanding of the amplification of global change in the polar regions (a bellwether of change coming to lower latitudes), it has been long-term observations that have allowed discernment of human-induced change from natural variability. Sustained observations are essential to understanding and modelling of complex coupled natural/human systems that vary spatially and on annual, decadal and longer timeframes. Observations underpin and reduce uncertainties in predictions of possible futures and inform policy decisions that can reduce the risks of unwanted outcomes. AAD and partners have collected diverse datasets for many years on various aspects of Antarctica. This includes geophysical data, sea and land-bound ice sheet data, atmospheric and oceanic data, satellite data, and data on fauna populations and ecosystems functioning. Some of the datasets are digitised; some are not. Some cover long spans of time and then stop. Some data are well curated and easy to access but others are not. Collection of long-term observations and high-quality data informs the focus and design of future research programs that will catalyse improvements in the models that uptake such data (for example major climate models), and will be essential for

developing a digital twin of Antarctica. These data streams need to be reliable (quality controlled and comparable over long timeframes) and easily accessible. Long-term data sets are essential to informing policies related to fisheries management, conservation science and environmental protection, and ongoing loss of biodiversity.

Findings

While considerable long-term monitoring has been conducted in the AAP over many years, most of it has been carried out in an uncoordinated manner which has resulted in data gaps and less than optimal use of the data gathered. Data quality and inter-comparability are often unknown or undocumented.

Goal

A well designed and comprehensive approach to data collection and storage on all aspects of East Antarctica and the surrounding Southern Ocean, with AAD creating the capabilities to be the central archive and storehouse of invaluable and irreplaceable historical datasets, and the recipient of future, long-term monitoring data streams of all kinds.

Recommendation 4: East Antarctic Monitoring Program (EAMP)

That Science Branch, with the support of the Australian Antarctic Data Centre, create, manage and be the custodian of a formal, long-term monitoring program (the East Antarctic Monitoring Program – EAMP), building on and extending monitoring done over decades by AAD and partners and ensuring maximum use of technological developments in data science, low-cost sensors, spaceborne sensors, and autonomous vehicles.

Establishing the EAMP will involve:

- determining the essential physical, biological and chemical variables to be measured, guided by relevance, feasibility and effectiveness
- determining the frequency and duration of measurements and the preferred data collection methods to be used in designing and/or continuing long-term monitoring through wide consultation with end-users
- ensuring the use of intercalibrated, state-of-the-art standardised methodologies for data collection
- implementation of quality assurance/quality control procedures to ensure the integrity and comparability of data over timeframes consistent with natural and human-induced change
- ensuring easy access to data and robust archival storage methods for timeframes that will span decades
- curating all past data collections including forensic investigations to rescue long-term datasets/records and other information in all forms; assessing and documenting the quality and value of archived data; and transferring all data to modern storage and preservation technologies to promote wide access by end-users.

The resulting data will be open access and formally curated, stored and quality controlled for the purposes of understanding long-term change and providing data streams of known quality to predictive systems such as large-scale models and digital twins. This dynamic data collection and appropriate software tools will together constitute the AAT Virtual Observatory, presenting all the monitoring material online in an accessible format, including real time where possible. The proposed EAMP will work closely with related national bodies such as IMOS, international programs such as the Southern Ocean Observing System (SOOS), and data products curated by SCAR (e.g. BEDMAP3,[16] Biodiversity.aq,[17] the International Iceberg,[18] and the Seismic Data Library System[19]).

[16] https://www.scar.org/science/bedmap3/home/
[17] https://www.biodiversity.aq
[18] https://www.scar.org/resources/iceberg-database/
[19] https://www.scar.org/sdls/

Expected Outcomes

Accessible, quality data collected over long-time spans that provide comprehensive coverage of the many and varied data needs to support Australian Antarctic science.

6.5 Integrated Digital East Antarctica (IDEA)

As noted above, there is a significant opportunity for Australia to boost its scientific presence across its Antarctic claim leveraging recent technology developments and its own expertise in data science and digital technologies.

Findings

The AAD's Australian Antarctic Data Centre (AADC), which sits outside the Science Branch, has made significant progress over the last few years, with a new strategy focussing on a modern digital architecture and tools to support data analytics and 'big data' research, and a new digital mapping program. In parallel, the AAPP has commenced a 'Digital Antarctica' initiative, defining standards for 'Findable, Accessible, Interoperable and Reusable' (FAIR) data. These important and welcome developments are consistent with the Australian Antarctic Science Strategic Plan and provide the platform for a new digital initiative. However, building on efforts by the AADC, there is now an opportunity for Science Branch to lead a major new national initiative to underpin future research capability and enhance its policy relevance by building a digital twin of East Antarctica. This initiative would emphasise the interoperability in 'FAIR' to establish a data rich prediction capability for East Antarctica.

Goal

Create, manage and maintain a digital twin of East Antarctica and surrounding Southern Ocean called Integrated Digital East Antarctica (IDEA).

Recommendation 5: Integrated Digital East Antarctica (IDEA)

5.1 That the Science Branch initiate and lead a new and ongoing 'Integrated Digital East Antarctica' (IDEA) program as a fundamental component of the Australian Antarctic Program. The IDEA program will integrate and leverage:

- the new AADC and AAPP digital capabilities
- Australia's expertise in other application areas in data science, remote sensing, large robotics, smart sensors, and modelling
- historic and future Australian data from the AAP, including from the AAPP, SRIs, GA, BoM, CSIRO, MNF, IMOS (including its Ships of Opportunity Facility) and the new icebreaker and field platforms
- international data, from SCAR programs and remote sensing platforms
- initiatives including the ACCESS NRI's leadership in simulation such that next generation simulation capabilities inform the development of a digital twin for East Antarctica.

5.2 That the geographic extent of IDEA be the whole of East Antarctica and the surrounding ocean, which fully incorporates the AAT and Australia's Exclusive Economic Zone claim; and its objectives be to:

- build and maintain the globally authoritative digital model (or twin) of East Antarctica with input from at least CSIRO, GA, BoM and the university sector
- enable integrated research programs (building from the data architecture noted above to include modelling, scenarios, and prediction) by all AAP participants.

These objectives have both geopolitical and scientific dimensions. The IDEA will be a modern (digital) expression of Australia's AAT sovereignty claim[20] (our digital footprint on the ice), facilitate collaboration with other national Antarctic programs including

[20] Following the passing of the 1933 Australian Antarctic Territory Act, the Australian Government decided that production of a comprehensive map of Antarctica would assist the consolidation of its territorial claims. The resulting map, published in 1939 (Bayliss and Cumpston, Department of the Interior) was recognised as 'the world's first reliable map of Antarctica'. A digital twin of East Antarctica, incorporating topographic, bathymetric and other spatially-referenced historic and current scientific data, would be the 21st Century equivalent.

through SCAR, and enable more ambitious multi-disciplinary 'big data' science. The IDEA will initiate and enable new science programs, by current and new researchers, without the cost of field work. IDEA could even be positioned as an Australian-led SCAR initiative.

Critical initial steps in developing the IDEA include:

- identify the research questions in the Decadal Plan which can only be addressed by developing the IDEA (this is an iterative process; the Decadal Plan should generate other science and geopolitical use-cases for the IDEA, including in the Antarctic Treaty System)
- review current Australian and international data holdings and monitoring programs against the science and policy user needs, to identify data gaps
- examine and assess existing digital twin initiatives to establish strategies that can be adopted by the Division
- develop programs to fill those gaps (including via international collaboration and remote sensing, where possible).

5.3 That these science and policy-driven applications and programs be led by Science Branch, in collaboration with the AAD's Technology & Innovation and Policy & International Branches. The technical architecture for the IDEA should be developed in consultation with AAP members, noting that several other Commonwealth agencies and universities have significant digital capabilities and experience.

Expected Outcome

A digital twin in which significant Antarctic and Southern Ocean research can be carried out, drawing on many years of data from Australia and international sources, to inform both modellers and those seeking to understand climate change drivers. It would establish Australia as a leader of countries with strategic interests aligned with Antarctica, and provide new policy-relevant science to assist Australia's claims on East Antarctica.

6.6 Science collaboration

Good collaboration is a fundamental feature of good science.

Findings

Australia's Antarctic science (and related geopolitical) interests will be best served by deep and enduring collaboration. The institutional arrangements recommended in the Clarke review to strengthen collaboration were not implemented, resulting in four separately funded Commonwealth Antarctic research programs – three of which have term-limited funding. This institutional arrangement can be strengthened through some incremental changes, leaving open the potential for a later step change. International collaborations also need to be strengthened, leveraging SCAR relationships and programs.

Goal

To strengthen the fabric of collaboration between the Branch and other Australian Antarctic science bodies, and between Australia and international science bodies.

Recommendation 6: Science collaboration

6.1 To maximise collaboration in Australian Antarctic science, that the Chief Scientist convene an advisory group to help her draft the Decadal Plan. Ideally, this group should include the leaders of the AAPP and the SRIs, and appropriate leaders from the other entities carrying out major Antarctic research, CSIRO, BoM and GA, as well as Science Branch itself.

6.2 That the Chief Scientist, with input from the advisory group, develop a collaboration program to deliver the Decadal Plan, including logistics support, data sharing and science symposia.

6.3 That, in developing the Decadal Plan, the Chief Scientist pursue opportunities for Australian leadership and participation in SCAR programs that are aligned with the

Plan. In particular, that the focus be on regional and continental data analytics and remote sensing programs that would link to the Australian data model but not require new logistics support. More generally, the Chief Scientist should examine possibilities for maximising collaboration with other polar programs, with a view to increasing science impact significantly and sharing expensive facilities.

6.4 That the Chief Scientist examine and report on the short and long-term research opportunities and collaboration which could be realised and strengthened through co-location of Hobart-based elements of the Australian Antarctic science community as a key element in the broader program of work by the Australian and Tasmanian Governments to develop a business case for the creation of a state-of-the-art Antarctic and Science Precinct at Macquarie Point.

6.5 That the Chief Scientist, in collaboration with the Council, develop a plan for further strengthening the Australian Antarctic science institutional model. This should include consideration of unimplemented recommendations from the Clarke Review and a submission to Government (through the Division and Department) for ongoing science funding following cessation of the AAPP and SRI programs. It should also include processes to second or otherwise engage high quality research groups from other institutions as required.

Expected Outcome

An Australian Antarctic Program where effective collaboration drives high impact science programs.

6.7 Science capability

The Review heard a consistent theme about the need for better succession planning within Science Branch. The lack of depth in many areas means the Division is highly exposed if key scientists retire or leave. And the long tenure of many scientists in the Division, as well as restrictions on staffing numbers, means there has been limited scope to bring in new researchers with fresh perspectives.

There is a need for more professional development opportunities for existing staff, including through targeted mentoring programs, secondments out and participation in international conferences.

There is also a need for a systematic approach to maintaining a steady stream of incoming early career researchers (ECRs – PhD students and postdoctoral fellows), though the Review noted and endorses the recent work already done by the new Chief Scientist in developing a Research Student Policy to underpin the engagement of students in the future. The Review notes there are many potential strategies for workforce development focused on ECRs. These could include: designation of an AAD champion for ECRs; consistent criteria for ECR engagement and resource support; partnerships with other ECR programs; workshops on research co-design; exploration of cost-effective individualised and collective support for ECRs (e.g. stipend or top-up scholarships, mentoring, skills development); and opportunities for joint ECR initiatives.

Succession planning, within and outside the Branch, is part of a broader need to ensure that Australia has the people, technology and science capabilities to address the science priorities identified in the proposed Decadal Plan. The Review heard many comments about the need to understand better Australia's current capabilities, and those which may be needed in the future.

Findings

The Decadal Plan will require a range of capabilities, but it is currently difficult to identify which capabilities may not currently exist or which may require further development. These capabilities must include the pipeline of future Antarctic science leaders, both in the Branch and in the Australian science community more broadly.

Goal

To ensure that Australia's Antarctic science priorities and programs, now and in the future, are supported by the necessary people, technology and science capabilities.

Recommendation 7: Science capability

7.1 That the Chief Scientist, in collaboration with the Council, AAPP and SRIs, determine the future Australian capabilities (people, technology, science) that will be required to deliver the Decadal Plan, map current capabilities against those needs, and initiate a program to fill any gaps. This process should be repeated every three years.

7.2 That the Chief Scientist develop a program of secondments from other Australian and international science bodies to strengthen Science Branch capabilities in strategic areas. (This program should be based on win-win-win principles – for the Branch, the home institution and for individual career development).

7.3 That a regular review cycle of research programs across the AAP, aligned to the three-year capability review, be encouraged.

7.4 That the Chief Scientist, in collaboration with the Council, AAPP and the SRIs, develop an integrated, cost-effective and best-practice program, with five and 10 year targets, to support development of future Australian Antarctic science leaders, at all levels (postgraduate, postdoctoral, early-mid career, principal investigator, Future Fellow). This program to include co-supervision, funding and international linkage arrangements.

Expected Outcome

The capabilities required to deliver on this and subsequent Decadal Plans are ensured.

6.8 Science infrastructure and logistics support

Antarctic and Southern Ocean science cannot occur without infrastructure and logistics support.

Findings

The availability of infrastructure and logistics support is a significant constraint on the scope, scale and volume of the science that can be performed in Antarctica and the Southern Ocean. While much of this support is provided by the AAD, other institutions in Australia (e.g. CSIRO; the Marine National Facility; IMOS and its Ships of Opportunity Facility) and overseas countries (e.g. France and PP *L'Astrolabe*; Korea and RV *Araon* and drill; New Zealand and RV *Tangaroa*; Japan and *Shirase*; and the Southern Ocean Observatory System (SOOS), a joint initiative of SCAR and the Scientific Committee on Oceanic Research) have assets and infrastructure able to support Australia's Antarctic and Southern Ocean science, although this capacity has not been fully scoped. The full Australian Antarctic Program will require a more coordinated approach across national (and potentially international) institutions to ensure the highest priority Australian science is supported by the limited infrastructure and logistics available. Any new allocative model should address the perceived conflict of interest which arises from the fact that currently the AAD Science Branch effectively competes with other research institutions for the limited logistics support that the AAD itself provides.

Goal

To ensure that the Australian Antarctic Program is underpinned by a strategic and coordinated approach to providing infrastructure and logistics support to enable the highest priority research to be conducted.

Recommendation 8: Science infrastructure and logistics support

8.1 That the Decadal Plan be informed by a coordinated overview of available national (and potentially international) science infrastructure and logistics support to ensure the expression of priorities and investment in research is matched by available operational support, particularly on ice.

8.2 That future decisions on the allocation of the available support be made by the Director, AAD, with advice from the Council and the Chief Scientist and other appropriate branch heads, in consultation with the heads of the AAPP and the SRIs, to help mitigate the potential for perceptions of conflict of interest.

Expected Outcome
Timely and high-quality logistics support for the highest priority research activities under the Decadal Plan.

6.9 Communication

A corollary of all the above is the need for more sophisticated communication between AAD and the Government, to ensure that AAD's science delivery has an impact on Australia's national interest in Antarctica and the Southern Ocean, as articulated broadly in the Commonwealth Government's *Australian Antarctic Strategy and 20 Year Action Plan.* This requires good networks so that timely interactions with the right people on the right issues can be conducted and the Division's own plan (a sub-set of the AAP Decadal Plan) can be developed and signed off at appropriate Departmental/Ministerial level, and regular review and updating can occur.

Strategies to improve and formalise communication channels should be led by AAD's Policy & International branch, but the Chief Scientist needs to be closely involved so that information relevant to science activities can flow both ways.

Several Government agencies indicated to the Review that they would appreciate short reports on the state of Australia's Antarctic science (e.g. DFAT, for use to demonstrate Australia's credibility in international forums).

In respect of AAD's communications with the public, the emphasis in recent years has been, understandably, on the new icebreaker and million year ice core. The fact that the AAD's focus is on science in Antarctica and the Southern Ocean needs to be reinforced, and its overall capability and contributions showcased globally.

Finding
Communication with Government about how AAD serves and can serve the national interest with 'science for impact' is not occurring at the appropriate level.

Goal
To ensure there is effective communication between AAD/AAP and the Government, and effective communication between all the science and logistics bodies it needs to interact with, nationally and internationally.

Recommendation 9: Communication
That the AAD, informed by the Chief Scientist and the heads of the Policy & International and Strategy & Communications branches, develop an appropriate ongoing Government communication strategy that covers the continuing AAD science/policy nexus, in the context of the proposed AAP Decadal Plan.

Expected Outcome
All appropriate Government and scientific agencies in Australia and overseas understand how the work of AAD, and the AAP more broadly, serves the national interest with 'science for impact'.

6.10 Leveraging capability in Tasmania

The Review noted the importance of the Antarctic program to the Tasmanian economy, and the reference to Tasmania's "status as the premier East Antarctic Gateway for science and operations" in the *Australian Antarctic Strategy and 20 Year Action Plan*. According to an April 2021 analysis for the Tasmanian Government,[21] in 2019-20 the Antarctic and Southern

[21] The Contribution of the Antarctic and Southern Ocean Sector to the Tasmanian Economy 2019-20 (Summary of a report to the Department of State Growth by Wells Economic Analysis, April 2021), Department of State Growth

Ocean sector contributed $229.4 million to the Australian economy, of which $158.7 million was spent directly in Tasmania. There were nearly 950 FTE jobs in the sector, representing 0.47 per cent of the Tasmanian job market. There were 52 PhD students, including 32 international students, at UTas researching Antarctic and Southern Ocean topics.

Tasmanian government representatives emphasised the willingness of their agencies to work with and share expensive facilities with AAD and other science institutions.

The Review noted the good cooperation in respect of research, facilities and education between the AAD, Tasmanian institutions (DPIPWE, UTas), and other research organisations with a presence in Hobart (CSIRO, ACEAS, IMOS). One example is the AAD/UTas cooperation on krill research, through the proposed use of UTas facilities at Taroona and the Centre for Antarctic and Southern Ocean Technology (CAST) spanning UTas, CSIRO and AAD. Retaining and strengthening existing cooperation and looking for new opportunities to cooperate should be a priority.

The Tasmanian Government told the Review that it is strongly committed to maintaining Hobart as the gateway to East Antarctica. It sees that a critical mass of science and logistics activity in Hobart increases the opportunities for other countries to collaborate and cooperate there, and noted the potential for increased work with the USA and the UK through AUKUS.

Finding
Antarctic research organisations in Tasmania cooperate well but more can be done.

Goal
Effective research collaboration between AAD and research organisations in Tasmania.

Recommendation 10: Leveraging capability in Tasmania
That the Chief Scientist foster a culture of intra-Tasmania cooperation in AAD and look for opportunities for strengthening cooperation with other Tasmanian entities which engage in Antarctic and Southern Ocean research.

Expected Outcomes
Enhanced cooperation and increased support from Tasmania to the Australian Antarctic Program, and an increase in the Tasmanian economy due to revitalisation of the AAP.

6.11 Getting there from here
The successful implementation of transformations requires five key elements: resources and effort; planning and mapping the way forward; allocating responsibilities for what will be delivered and to what standard; governance and external oversight; and regular reporting on progress.

Findings
Most AAD stakeholders are not clear about the purpose and extent of the science carried out in AAD and how it links to the national interest and the interests of other stakeholders. The overall quality and impact of the science was perceived as mixed (which the Review also observed) - some is of world standard; some has high quality aspects but is not well connected to related major initiatives; some shows potential; and some is of much lower quality. Many Science Branch staff are demotivated; the culture of the Branch needs attention. Without talented and committed staff, galvanised by a clear vision and a shared sense of purpose, Australia will not be able to deliver the Decadal Plan. There are many talented scientists in Science Branch; ensuring they have a role in shaping the Plan and the new directions of the Branch is critical.

https://www.stategrowth.tas.gov.au/__data/assets/pdf_file/0009/289503/Summary_of_the_Report_on_the_Value_of_the_Antarctic_Sector_to_Tasmania_2019-20.PDF

Goal

To provide guidance on the early steps required to transform the quality, relevance and impact of Science Branch.

Recommendation 11: Getting there from here

11.1 That, under the guidance of the Science Council, the Science Branch move rapidly to do the work needed to develop the Decadal Plan. This will involve:

- developing with the help of Policy & International Branch a sophisticated understanding of how Antarctic and Southern Ocean science can serve Australia's needs and articulating these needs in a clear statement that spells out customer agencies and timeframes and by when these needs have to be met
- auditing what is available already to help deliver on these needs including: current projects carried out by all organisations in the AAP, noting delivery responsibilities and timeframes; international Antarctic science collaborations between Australia and other nations; and data collections (historical and recent; national and international) of aspects of East Antarctica and the surrounding ocean
- identifying the capabilities (people, technology, science) required for delivery of the Decadal Plan, mapping them against current capabilities, and developing a program to fill the gaps – for Science Branch, this should include high quality secondments to build its own capability
- consulting all relevant agencies and research organisations
- drafting the Plan with a view to having full consultation finished and Ministerial sign off by the end of June 2022.

11.2 That new structures needed to implement the policy and delivery roles for Science Branch be implemented quickly, with the aim of being in place by the end of June 2022. Significant support and training will be needed to help staff transit to new roles and take on new responsibilities.

11.3 That Science Branch work with Technology & Innovation Branch to implement the Antarctic Monitoring Program and to scope the Integrated Digital East Antarctic program with a view to having funding support for IDEA by the end of 2022.

Expected Outcome

An effective start on the implementation of the recommendations of this Review.

7. Implementing recommendations would be enabled by AAD being an executive agency

Over the course of the Review, several Australian and international stakeholders commented on the unusual administrative arrangement of the Australian Antarctic operator, namely AAD (and hence Science Branch), being embedded as a division of a department, rather than being a government agency in its own right. While outside the Review's Terms of Reference, the Review observes that establishing the AAD as a Commonwealth Executive Agency (possibly named the Australian Antarctic Agency) within the DAWE portfolio would align with the Review's recommendations and enhance their implementation.

The other Commonwealth science bodies engaged with the Australian Antarctic Program, GA, CSIRO and BoM, are all executive agencies or statutory authorities. Most other Commonwealth activities with major ongoing science and operational roles, including the Great Barrier Reef Marine Park Authority (GBRMPA), the Australian Institute of Marine Science (AIMS) and the Australian Nuclear Science and Technology Organisation (ANSTO), are similarly structured.

Transforming the AAD into an Executive Agency would be a tangible expression of Australia's commitment to Antarctica and the Treaty System, leveraging the new logistics capabilities and an enhanced science program. While still operating under Government and

Ministerial direction, the ‘agency’ status would enhance visibility, strategic planning, domestic and international collaboration, leadership, staffing and authority. AAD is currently a peer of many Australian and international entities in role, and, as an Agency, would also become a peer in structure and status. These ‘agency’ benefits would flow directly to the Science Branch, to the Science Council and to the overall AAP.

8. Vision 2024

The recommendations above are practical mechanisms for ensuring the contribution of AAD’s Science Branch to a coherent, active, world-leading Australian Antarctic Program that meets Government policy objectives in Australia’s national interests and contributes to the big science needed to address world problems.

It is possible now to visualise an Australian Antarctic Program that, within three years, delivers science that collaboratively, constructively, creatively and demonstrably leads critical initiatives. The Review’s vision is set out below.

By 2024, the Australian Antarctic Science Council is the lead government advisory body for the Australian Antarctic Program. Its most important responsibility is updating and reporting on implementation of the Decadal Plan for Antarctic science completed in 2022. The main work for this Plan was carried out by the Chief Scientist supported by an advisory group comprising leaders of the other major Antarctic research endeavours in Australia.

Science Branch has an essential role in the Australian Antarctic Program. Unlike the situation up to 2021, it now leads the Program, coordinating the work of the Program’s constituent research bodies, commissioning and sometimes conducting research to deliver the Decadal Plan, and providing science policy advice to Government to support Australia’s national Antarctic and Southern Ocean interests.

The Branch has a more focused delivery role than before. It undertakes research when it is essential to deliver Australia’s Antarctic and Southern Ocean science priorities and capabilities and the research is not able to be commissioned from another research organisation outside the Division, but only if that research also satisfies the agreed principles.

The East Antarctica Discovery Decadal Plan – which articulates research needed to answer a (small) number of key questions about East Antarctica and how it affects Australian and world weather and climate – was signed off and resourced by the Government in 2022, on the advice of the Council. Under its ‘big challenges agenda’ this Plan incorporated the work of the AAD’s Climate Program, Krill Program, the AAPP and the two SRIs. Two other major features (which involved new funding) are the East Antarctic Monitoring Program (EAMP) and the ambitious Integrated Digital East Antarctica (IDEA), effectively the building of a digital twin, drawing on data from a wide variety of Australian and international sources present, historical and new. The IDEA spans all the other projects (taking data from them and supplying data and modelling to all of them) under the Plan and allows for more cost-efficient, high-impact research than that requiring ship and base time.

Under the Plan, more new funding will come on stream in 2025 when SRI ACEAS finishes. This will allow the set of next ‘big challenge’ projects to be commissioned. The process for commissioning this will be managed by the Chief Scientist, who has responsibility for implementing the Decadal Plan.

Further major funding streams will come on as SRI SAEF winds up in 2028 and the AAPP in 2029. From then on, the funding will all flow through the AAD and on to those institutions and collaborative mechanisms best placed to deliver the highest quality science in the most effective way, with the funding spent in accordance with the Plan. The Plan is refreshed every 3 years taking into account new challenges and issues in Antarctica and the Southern Ocean and the results of the 3-yearly reviews of the existing projects funded under the Plan.

As well as the ‘big challenges agenda’ the Decadal Plan covers other important aspects of Australian Antarctic Science including:

- provision of science to support the Treaty, and arrangements under it such as CCAMLR, and other Australian government agencies. A small unit in Science Branch coordinates this, carrying out some of the work directly and commissioning work as necessary from a variety of prequalified providers. The scientists in this unit may be attached to projects in the big challenges agenda as well
- provision of science for Antarctic environment protection and remediation. This is also coordinated through a small unit in Science Branch, carrying out some of the work directly and commissioning work as necessary from a variety of prequalified providers. The scientists in this unit may also be attached to projects in the big challenges agenda particularly through SAEF
- a process to build up and support Australia’s involvement in international Antarctic science particularly through SCAR. The Chief Scientist has a working party to advise her on this and funding to kickstart initiatives. This work is informed by Science Branch’s ongoing monitoring of polar and related research worldwide
- coordination of logistics support for Australian Antarctic science, managed through Operations and Safety Branch, working closely with the Chief Scientist on assignment of AAD-managed infrastructure and on linking to other infrastructure such as that managed through IMOS and CSIRO
- next generation Antarctica – an integrated program of salary, mentoring and logistics support to attract top ECR scientists into Antarctic research especially through the projects under the ‘big challenges agenda’
- promotion of Australian Antarctic science through media, prizes, specialist meetings, symposia, conferences and citizen science.

Because of the high levels of reform, funding and coordination under the East Antarctica Discovery Decadal Plan, Australia’s international reputation for Antarctic science is fast improving as Australia is now transforming the world’s knowledge of East Antarctica and its impact on other geophysical systems.

This reputation is also enhancing the role of Tasmania as the gateway to East Antarctica. Through increased international collaborations and highly focused science addressing the ‘big challenges’, a critical mass of high-quality science expertise and infrastructure makes an increasing contribution to the Tasmanian economy.

9. Conclusion

For Australia to have an extremely strong Antarctic and Southern Ocean program, it needs a lively and high functioning Science Branch. Revitalising the Science Branch can only be addressed in the context of the wider Australian Antarctic Program, and more generally in the context of international Antarctic programs.

There are two key recommendations of this Review: that the Division adopt as its core value that science is at the centre of all its activities; and that a Decadal Plan for Australian Antarctic and Southern Ocean science be developed to ensure a comprehensive approach to identifying, conducting and applying the Antarctic and Southern Ocean research that is vital to Australia’s interests. Implementation of these two recommendations, together with the nine other related recommendations to strengthen the Australian Antarctic Program, is critical if Australia is to have a strong international science voice in the big global challenges of the age, and a strong geopolitical influence in East Antarctica.

Glossary of Acronyms

AAD	Australian Antarctic Division, in DAWE
AADC	Australian Antarctic Data Centre
AAP	Australian Antarctic Program
AAPP	Australian Antarctic Program Partnership
AASSP	Australian Antarctic Science Strategic Plan
AAT	Australian Antarctic Territory
ACEAS	Australian Centre for Excellence in Antarctic Science, a Special Research Initiative of the Australian Research Council
AASSP	Australian Antarctic Science Strategic Plan
ACCESS-NRI	Australian Community Climate and Earth System Simulator – National Research Infrastructure
AIMS	Australian Institute of Marine Science
ANSTO	Australian Nuclear Science and Technology Organisation
ARC	Australian Research Council
BAS	British Antarctic Survey
BoM	Bureau of Meteorology
CAST	Centre for Antarctic and Southern Ocean Technology in Tasmania
CCAMLR	Commission for the Conservation of Antarctic Marine Living Resources (linked to the Antarctic Treaty System)
COMNAP	Council of Managers of National Antarctic Programs (linked to the Antarctic Treaty System)
COSIMA	Consortium for Ocean-Sea Ice Modelling in Australia
DAWE	Commonwealth Department of Agriculture, Water and the Environment
DFAT	Commonwealth Department of Foreign Affairs and Trade
DPIPWE	Tasmanian Department of Primary Industries, Parks, Water and the Environment
EAMP	East Antarctica Monitoring Program (proposed in this report)
ECR	early career researcher
FRDC	Fisheries Research & Development Corporation
FTE	full-time equivalent
GA	Geoscience Australia
GBRMPA	Great Barrier Reef Marine Park Authority
IDEA	Integrated Digital East Antarctica (proposed in this report)
IMAS	Institute of Marine and Antarctic Studies, University of Tasmania
IMOS	Integrated Marine Observing System (a National Collaborative Research Infrastructure Strategy capability)
IPCC	Intergovernmental Panel on Climate Change
IWC	International Whaling Commission
KOMBI	Krill Observational Mooring for Benthic Investigations
MNF	Marine National Facility (part of CSIRO)
NCAR	National Committee for Antarctic Research (a committee supported by the Australian Academy of Science)
NESP	National Environmental Science Program
SAEF	Securing Antarctica's Environmental Future (a Special Research Initiative of the Australian Research Council)
SCAR	Scientific Committee on Antarctic Research (a committee of the International Science Council)
SOOS	Southern Ocean Observing System
SRI	Special Research Initiative of the ARC (there are two for Antarctica: ACEAS and SAEF)
UNFCCC	United Nations Framework Convention on Climate Change
UTas	University of Tasmania

Attachment A – Terms of Reference

1. Assess the role of AAD's science branch within the Australian Antarctic Program.
2. Consider the quality, relevance and impact of AAD's science over the period 2017-21 and determine the extent to which it delivered on government priorities and outcome areas identified in the Australian Antarctic Strategic Science Plan (AASSP) and 20 Year Strategy & Action Plan.
3. Consider whether there are examples of scientific best practice that AAD could adopt from national (other Australian Antarctic research sectors) or international polar research programs, in the context of priorities/capability and resourcing.
4. Consider 'fitness for purpose' to deliver AASSP 2021-2030, including identification of capability/resourcing gaps. Make recommendations for improvement if appropriate.

Attachment B – Panel member biographies

Emeritus Professor Mary O'Kane AC FTSE (Chair)
Mary O'Kane is Chair of the NSW Independent Planning Commission, Aurora Energy, and Sydney Health Partners, and Executive Chair of O'Kane Associates, a company specialising in major reviews. She is also Chair of the advisory boards of the Institute of Marine and Antarctic Studies at the University of Tasmania and the Australian Centre of Excellence in Antarctic Science. She was NSW Chief Scientist & Engineer from 2008-2018; and Vice-Chancellor of the University of Adelaide from 1996-2001. She was a Trustee of the New Zealand Antarctic Research Institute from 2012-18.

For the last 25 years, Mary has served on many Australian and overseas boards and committees in the public and private sectors, especially related to research, engineering, ICT, energy, and international development. She is particularly experienced in the governance of research companies and organisations having been a member of the Australian Research Council and chair of its Research Grants Committee, member of the Board of CSIRO, member of the Board of NICTA, member of the Cooperative Research Centre Committee, and member of the boards of 12 CRCs including chair of four of them. Recently she was appointed chair of the major industry/university research centre funding program in Austria, the first foreigner to be appointed to this role.

Mr Drew Clarke AO FTSE
Mr Clarke has served as Secretary of the Australian Government Department of Resources and Energy and of the Department of Communications, and Chief of Staff in the Office of the Prime Minister. His 40 years in the Australian Public Service encompassed leadership of applied science agencies, industry innovation programs, data policy, and energy policy and technology programs.

He has degrees in Applied Science from RMIT and a Master of Science from The Ohio State University, and is a Fellow of the Academy of Technological Sciences and Engineering. Mr Clarke is currently Chair of the Australian Energy Market Operator, Chair of the Advisory Board of Securing Antarctica's Environmental Future ARC Special Research Initiative, and a Director of CSIRO and of NBNCo. He also has several advisory roles in energy research and technology.

Drew began his public sector career working as a surveyor in Australia and Antarctica. His Antarctic experience includes fieldwork in Enderby Land, chairing the SCAR Working Group on Geodesy and Geographic Information, and leading policy reviews on Antarctic data management and science governance.

Mr Martin Exel
Mr Exel has been in the seafood sector for 40 years; and with Austral Fisheries (an Australian seafood business) since 1997. He shares that role also as Managing Director of SeaBOS (Seafood Business for Ocean Stewardship) since July 2019, which is a collaborative venture between ten of the world's largest seafood businesses and the Stockholm Resilience Centre in Sweden. The aim of that collaboration is to lead a global transformation to sustainable seafood production and a healthy ocean.

Mr Exel has worked in various roles in seafood including from industry, government, and academia. He holds a BSc from Victoria University of Wellington (NZ), a Graduate Diploma in Fisheries Technology from the Australian Maritime College, and is a passionate recreational angler.

Mr Greg Johannes
Mr Johannes has more than 20 years of leadership experience in the public, private, not-for-profit and research sectors. His roles have included being Head of the State Service and Secretary of the Department of Premier and Cabinet in Tasmania. In 2015 he was made a National Fellow of the Institute of Public Administration Australia for his outstanding contribution to the public sector in Australia over many years.

Greg has a deep interest in the marine science community and has previously been on the boards of both the Antarctic Climate and Ecosystems CRC and the Institute for Marine and

Antarctic Studies. He is currently Chair of the Blue Economy Cooperative Research Centre and the Independent Chair of the Management Committee for the Australian Antarctic Program Partnership, in addition to his work as a management consultant.

Professor Mahlon "Chuck" Kennicutt II

Professor Kennicutt is a founding member and former Director (1998-2004) of the Geochemical and Environmental Research Group (GERG) and is Professor Emeritus of Oceanography at Texas A&M University (TAMU). He received his BS degree in chemistry from Union College (1974) and a PhD in Oceanography (1980) from TAMU. At GERG he was involved in more than $100 million of research funding; spent more than 575 days at sea; mentored 21 MS and PhD graduate students; published over 130 scientific articles and nine chapters in books; and participated in submersible cruises on the Johnson Sea-Link, the Diaphus, the U.S. Navy NR-1, and Pisces II submarines. In 2004, Professor Kennicutt was named Director of Sustainable Development in the Office of the Vice President for Research at TAMU and continued to lead the Sustainable Coastal Margins Program created in 2000. In the Oceanography Department he taught oceanography, polar science, and science and policy. His research interests include environmental chemistry, organic geochemistry, the fate and effects of pollutants, environmental monitoring, ecosystem health, Antarctic environmental issues, and sustainability science.

Professor Kennicutt first went to Antarctica as a graduate student in 1977, which marked the beginning of more than 22 years of research on the impact of humans on Antarctica. He served as the US Delegate to the Scientific Committee on Antarctic Research (SCAR) for 14 years and was a SCAR Vice President from 2004-2008 and President from 2008-2012. He was an *ex officio* member of the National Academies Polar Research Board for 14 years, a science advisor to the US State Department Antarctic Treaty Delegation for seven years, and attended 10 Antarctic Treaty Consultative Meetings. He has served on numerous US National Academies' committees including on the effects of oil and gas exploration on the North Slope of Alaska. He is currently a Trustee and Chair of the International Science Panel of the New Zealand Antarctic Research Institute. Professor Kennicutt has been named a National Associate of the US National Academy of Sciences for life and was awarded the US Antarctic Service Medal. An Antarctic geographic feature was officially named Kennicutt Point in 2006.

Professor Helene Marsh AO FAA FTSE

Professor Marsh is a marine conservation biologist with more than 40 years' experience in research into species conservation, management and policy with particular reference to tropical coastal and riverine megafauna, especially marine mammals. She is a fellow of the Australian Academy of Science and the Australian Academy of Technological Sciences and Engineering and her research has been recognised by awards from the Pew Foundation, the Society for Conservation Biology, the American Society of Mammalogists and the Australian Marine Science Association.

The policy outcomes of her research include significant contributions to the science base of the conservation of dugongs in Australia and internationally at a global scale (IUCN, UNEP, Convention for Migratory Species) and by providing advice to the governments of some 14 countries. Professor Marsh chairs the Australian Threatened Species Scientific Committee, a statutory committee that makes recommendations to the Federal Minister for Environment and is a Vice President and Secretary Biological Sciences of the Australian Academy of Science.

She is a past President of the international Society of Marine Mammalogy, Co–chair of the IUCN Sirenia Specialist Group and on the editorial boards of *Conservation Biology*, *Endangered Species Research* and *Oecologia*. Professor Marsh was deputy co-chair of the 2015-2016 ACOLA Review of Research Training and recently led a research program on preparing graduate students for industry careers in the Blue Economy. Professor Marsh is proud of the accomplishments of the 60 PhD candidates that she has supervised to graduation, all of whom have taught her a lot.

For further information see https://research.jcu.edu.au/portfolio/helene.marsh.

Professor Andy Pitman AO FAA
Professor Pitman is a Professor in climate science at the University of New South Wales. He is the Director of the ARC Centre of Excellence for Climate Extremes. He has 35 years' experience, and broad interests extending across climate modeling, climate change, and climate extremes. Professor Pitman has been a lead author on the Intergovernmental Panel on Climate Change, winning the Nobel Peace Prize in 2007. He was a review editor of the 2013 report. He has had multiple senior advisory roles in climate science for the Federal Government and the NSW State Government, as well as senior national roles in e-research infrastructure strategy.

He won the Priestley Medal in 2004, the AMOS Medal in 2009, the NSW Climate Scientist of the Year in 2010, the Royal Society of Victoria medal in 2020 and was elected Fellow of the Australian Academy of Science in 2021. He is also a Fellow of the American Meteorological Society and the Australian Meteorological and Oceanographic Society.

Dr Ian Poiner FTSE
Dr Ian Poiner is a highly respected tropical marine scientist with a long history of involvement in ecology, fisheries and conservation. He is Chairperson, Great Barrier Reef Marine Park Authority, Board Member of the Australian Maritime Safety Authority and Patron of the Australian Marine Science Association.

His recent roles include, Chair of Australia's Integrated Marine Observing System; Marine National Facility Steering Committee; the Reef and Rainforest Research Centre; Australian and New Zealand International Ocean Discovery Program; and CSIRO Oceans and Atmosphere Advisory Committee.

Following a successful research career at CSIRO (1985–2004), Dr Poiner served as the CEO of AIMS from 2004 to 2011. He was a member of the International Scientific Steering Committee of the Census of Marine Life from 2002 and its Chair from 2007 to 2013. From 2012 to 2016, he was Chair of the Gladstone Healthy Harbour Partnership Science Panel.

In 2008, Dr Poiner was appointed a Fellow of the Australian Academy of Technological Sciences and Engineering. In 2013 he was awarded an Honorary Doctor of Science by JCU.

Dr Jenny Stauber FAA FTSE
Dr Stauber is a Chief Research Scientist at the Centre for Environmental Contaminants Research, CSIRO Land and Water in Sydney. She is currently Visiting Professor at South China Normal University, Guangzhou, China and was Deputy Chief and Acting Chief of CSIRO Land and Water from 2008-2014. Dr Stauber is an aquatic ecotoxicologist, with expertise in the bioavailability and toxicity of contaminants in marine and freshwater systems, environmental risk assessment, downstream impacts of mining, ecogenomics, human toxicology and the derivation of toxicant water and sediment quality guidelines.

Dr Stauber chairs the Queensland Alliance for Environmental Health Science Management Committee and is a member of Australia's Independent Expert Scientific Committee (IESC) on Coal Seam Gas and Large Coal Mining Development and the Alligator Rivers Region Technical Committee, both reporting to the Environment Minister through DAWE. Jenny has chaired and served as expert ecotoxicologist on many World Health Organisation chemical review boards, together with the NSW EPA Board and a large number of expert advisory panels to the Australian government and industry on areas as diverse as chemical contaminants, reef water quality, uranium mining, coal seam gas, hazardous waste, chemicals risk assessment and water quality guidelines. She is a graduate of the Australian Institute of Company Directors and a SETAC Fellow. She is a Fellow of both the Australian Academy of Science and the Australian Academy of Technology and Engineering. She was a recipient of Australia's Eureka Prize in 2006 and has authored over 375 journal papers, book chapters and reports.

Attachment C – Consultation interviewees

Commonwealth Government (including Australian Antarctic Program entities)	
Minister for the Environment	The Hon Sussan Ley MP
Department of Agriculture, Water and the Environment	Secretary, Mr Andrew Metcalfe AO
Department of Agriculture, Water and the Environment	Deputy Secretary, Ms Lyn O'Connell PSM
Antarctic Science Foundation	Dr Katherine Woodthorpe (also former chair of former Antarctic Science & Ecosystems CRC)
Australia's Chief Scientist	Dr Cathy Foley AO PSM
Australian Antarctic Partnerships Program	Program Leader, Professor Nathan Bindoff
Australian Antarctic Science Council	Chair, Mr Philip Marcus Clark AO
Australian Centre for Excellence in Antarctic Science (an ARC Special Research Initiative)	Director, Professor Matt King
Australian Nuclear Science and Technology Organisation	Group Executive Nuclear Science and Technology, Professor Andrew Peele
Bureau of Meteorology	CEO and Director of Meteorology, Dr Andrew Johnson
CSIRO	CEO, Dr Larry Marshall
CSIRO	CSIRO Fellow and Research Team Leader, Dr Steve Rintoul
CSIRO	Director, Oceans and Atmosphere, Dr Dan Metcalfe
CSIRO Marine National Facility	Director, National Collections & Marine Infrastructure, Ms Toni Moate
Department of Defence	Chief, Maritime Division, Defence Science & Technology Group, Professor Emily Hilder
Department of Foreign Affairs and Trade	Assistant Secretary, Sanctions, Crime and Sea Law Branch, Legal Division, Mr Ben Playle
Department of Prime Minister and Cabinet	Climate Coordinator, Mr James Larsen
Geoscience Australia	Director, Dr James Johnson
Integrated Marine Observing System	Director, Dr Michelle Heupel
Securing Antarctica's Environmental Future (an ARC Special Research Initiative)	Director, Professor Steven Chown
International committees and programs	
British Antarctic Survey	Director, Professor Dame Jane Francis FRS
Korean Polar Research Institute	President, Dr Sung-Ho Kang
Antarctica New Zealand	Chief Executive, Ms Sarah Williamson, with Chief Scientific Advisor, Professor John Cottle
Scientific Committee on Antarctic Research	President, Dr Yeadong Kim Past President, Professor Steven Chown
Wider research sector	
Australian Research Council	Executive Director, Mathematics, Physics, Chemistry and Earth Sciences, Professor Craig Simmons, with Director, Major Investments, Ms Liz Visher
Director, former Antarctic Gateway Partnership (an ARC Special Initiative), University of Tasmania	Emeritus Professor Richard Coleman

Institute of Marine and Antarctic Studies (IMAS), University of Tasmania	Mr Terry Bailey, Executive Dean, College of Sciences and Engineering, University of Tasmania, (formerly Executive Director, IMAS)
National Committee for Antarctic Research of the Australian Academy of Science	Chair, Professor Nerilie Abram
Universities Australia	Chair, Deputy Vice-Chancellors (Research) Group, Professor Sue Dodds, with Members of Deputy Vice-Chancellors (Research) Group at scheduled meeting, and Director of Research Policy, Ms Liz Eedle
Vice-Chancellor, University of Tasmania	Professor Rufus Black
Tasmanian Government	
Minister for Primary Industries and Water, Minister for Resources, and Minister for Energy and Emissions Reduction	The Hon Guy Barnett MP
Department of Primary Industries, Parks, Water & Environment, and Environmental Protection Authority	Secretary, Mr Tim Baker, with Director, Mr Wes Ford
Fishing industry stakeholders	
Australian Longline Pty Ltd	Managing Director, Mr Malcolm McNeill
Fisheries Research & Development Corporation (FRDC)	Managing Director, Dr Patrick Hone
Austral Fisheries Pty Ltd	CEO, Mr David Carter, with Senior Manager Environment and Policy, Mr Rhys Arangio (also Executive Officer, Coalition of Legal Toothfish Operators (COLTO))
Other individual stakeholders with past or present links to AAP	
Antarctic Conservation Manager, WWF Australia	Ms Emily Grilly
Active university researcher	Dr Suzie Reichman, Associate Professor at University of Melbourne
Former PhD student with AAD co-supervisor	Dr Darren Koppel
Former Director, AAD; and CEO, former Antarctic Climate and Ecosystems Cooperative Research Centre	Dr Tony Press
Australian Antarctic Division staff	
Mr Kim Ellis, Director, AAD	
Professor Nicole Webster, Chief Scientist	
Mr Phil Boxall, General Manager, Technology and Innovation Ms Kelly Buchanan, General Manager, Strategy and Communications Mr Charlton Clarke, General Manager, Operations and Safety Mr Stu Gibson, Acting General Manager, Assets and Infrastructure (also interviewed on Davis Aerodrome Project) Ms Gaia Puleston, General Manager, Policy & International (also interviewed with Gill Slocum and Ewan McIvor from Policy & International)	
Dr Johnathan Kool, Manager Data Centre (also chair of SCAR's Standing Committee on Antarctic Data Management) and Mr Rob Jennings, Business Analyst	
Mr Andy Sharman, Environmental Manager, Assets and Infrastructure Branch	

Attachment D – Science Branch/Review meeting program

Thursday 14 October

8.30am	Panel meets with Director, AAD, Kim Ellis
9am	Panel meets with Chief Scientist, Nicole Webster
9.30am	Panel meets with Chief Scientist and the 3 program leaders: Tas van Ommen, Antarctic Climate Catherine King, Environmental Protection Aleks Terauds, Marine Conservation & Management
10.30am	Morning tea break
11am to 12.15 pm	Panel meets with 2 Antarctic Climate teams *(and 1 on Friday)*
11am	*Atmosphere & Ice Sheet* (interview lead: Andy)
11.45am	*Sea Ice* (interview lead: Chuck)
12.15pm	Panel meets with Early Career Researchers
12.45pm	Lunch break
1.30pm	Panel meets with Dirk Welsford, Science Convenor, DAWE
2pm to 4.45pm	Panel meets with all Marine Conservation & Management teams
2pm	*Southern Ocean Ecosystems and Monitoring* (interview lead: Ian)
2.45pm	*Cross-Program Projects* (interview lead: Ian)
3pm	*Fisheries Ecology and Management (incl FRDC-funded staff employed through UTas)* (interview lead: Martin)
3.45pm	Afternoon tea break
4.15 pm	*Wildlife Ecology and Management* (interview lead: Helene)
4.45pm	Panel meets with Chief Scientist and Manager, Science Planning and Coordination (Rhonda Bartley)
5.15pm	End day one

Friday 15 October

8.15am to 9am	Panel meets with 3rd Antarctic Climate team
8.15am	*Ice Cores* (interview lead: Chuck)
9am to 11.30am	Panel meets with all Environmental Protection teams
9am	*Environmental Remediation and Restoration* (interview lead: Jenny)
9.45am	*Coastal Marine Ecology* (interview lead: Ian)
10.15am	*Environmental Toxicology* (interview lead: Jenny)
10.45am	Morning tea break
11am	*Biodiversity Conservation* (interview lead: Helene)
11.30am	Initial reflections and discussion
12.30pm	Lunch break
1.15pm	Discussion continues
3.30pm	Afternoon tea break
3.45pm	Discussion continues, and panel develops findings
5.30pm	Feedback to AAD Chief Scientist
6pm	Close