

AAPP Progress Report January-June 2020

Milestone number	Milestone name and description	Due date
002	Antarctica's influence on Climate and Sea Level	30/06/2029

(4000 max)

Theme 1 consists of three projects: Atmosphere; Ice Cores; and Ice Sheets. Progress in the Atmosphere project has been relatively unaffected by the COVID-19 disruption, primarily due to the focus in years 1 and 2 on the analysis of existing data sets. Dr Marc Mallet continued synthesising cloud, aerosol and meteorological observations from recent field campaigns in the Southern Ocean and the evaluation the high-resolution city version of Australia's ACCESS model for this region. Dr Mallet commenced implementation of new machine learning algorithms to better understand the dominant drivers of Southern Ocean cloud properties. The major overview paper of Southern Ocean field experiments has been submitted to BAMS and includes several AAPP members as co-authors. Post-processing a range of atmospheric data sets continues, including Macquarie Island Lidar, ship and Davis Station micro rain radar, and aerosol data from the CAPRICORN voyage. Davis Station cirrus analysis is nearing finalisation and a cloud radiative effect manuscript is nearing completion. The Ice Cores project appointed Dr Tessa Vance (Australian and Antarctic Palaeoclimate Scientist) and commenced on 1 April 2020. The COVID-19 disruptions have led to the restriction of access to critical laboratory facilities and caused delays in the trace chemical analysis of the Mount Brown South (MBS) core. Work on this core is now expected to restart in Q1 2021. Discrete water stable isotope analysis of the MBS core has been delayed due to COVID-19 slowing the repair of equipment in the United States. Progress has been made towards completing the isotopic analysis for the Law Dome 2000-year rainfall proxy at the UTAS Central Science Lab and should be completed by Q1 2021. Investigation of sea-ice proxies using chloride and methane-sulfonic acid across three ice-core sites is ongoing. In addition, Continuous Flow Analysis development is continuing with progress in developing control software for this equipment. The instrument and method for measuring hydrogen peroxide has been tested successfully by analysing sections of the MBS ice core. The electrical conductivity meter has been integrated and a new ice melting head prototype has been designed. Several members of the project provided input into presentations for AMOS 2020, February 2020 in Fremantle, WA. The Ice Shelves project had three research associates commence on 1 April 2020, Dr Sue Cook (Glaciologist – modelling), Dr Sarah Thompson (Glaciologist – remote sensing), and Dr Chen Zhao (Ice/Ocean systems analyst). This project is largely unaffected by the COVID-19 disruption as the early years do not involve fieldwork or lab-based work. Research examining continent-wide ice shelf basal melt rates resulting in three papers that have been submitted to The Cryosphere, Geoscientific Model Development and Geophysical Research Letters. A further two papers are currently in draft using phase-sensitive radar to monitor variability in basal melt rates on the Totten Ice Shelf, a region thought to be particularly vulnerable to high rates of ocean-driven melt. Work on the 1st Marine Ice Sheet-Ocean Model Inter-comparison Project will also explore the sensitivity of simulated basal melting rates. However, progress on the Realistic Ice-sheet/ocean State Estimates (RISE) project, which aims to compile and compare differing estimates of basal melt, has currently stalled and would benefit from additional effort to facilitate the next stage of analysis and publication. Data from helicopter-borne radar and TerraSAR-X satellite imagery from some East Antarctic sites is currently being analysed. This work will assess our ability to identify the fractures which drive iceberg calving under a range of surface conditions. A new grant for further access to TerraSAR-X satellite imagery is submitted and will allow a more extensive analysis of fracture and calving on Antarctic ice shelves.

Milestone number	Milestone name and description	Due date
003	The Future of Antarctic Sea Ice Krill and Ecosystems	30/06/2029

(4000 max)

Theme 3 consists of two projects: Sea Ice; and Krill and Ecosystems. The Sea Ice project had three research associates commence in the reporting period. They are Dr Will Hobbs (Sea ice-ocean modelling), Dr Alex Fraser (Sea ice remote sensing), and Dr Pat Wongpan (Quantitative sea ice biogeochemist/ecologist). Despite COVID19 disruption, work has progressed towards Milestone 003. Various contributions to advance knowledge of field-, lab-, modelling- and remote-sensing based information on (physical) processes driving the evolution of Antarctic sea ice has been made. For example, Dr Hobbs analysed the 2016 sea-ice minimum using the ACCESS-OM2-01 model, with initial results presented at the COSIMA workshop in May 2020. Work on sea-ice processes and change interaction with and affecting ice shelves in East Antarctica has resulted in a paper submitted to Earth System Science Data Discuss. Two papers are in review to show how the East Antarctic sea-ice environment varies and changes, and which processes are responsible (Francis et al; Fraser et al). Analysis of field-based information on biological and ecosystems properties of Antarctic sea ice is ongoing. The Krill and Ecosystems project had two research associates commence in the reporting period, Dr Christine Weldrick (Zooplankton ecologist) and Dr Robert Strzeppek (Phytoplankton Ecologist). Dr Weldrick participated on a Japanese research voyage (Umitaka-Maru) in January 2020. Onboard ecosystem studies included bringing live zooplankton to Hobart for pilot trials of lab-based culturing of copepods. COVID-19 has delayed lab-based work on identification and enumeration of zooplankton samples from the ENRICH voyage and this work is now due to be completed in late 2020. With German colleagues, the krill sampling was completed for a long-term experiment (1-year) into effects of temperature and CO₂ on adult krill physiology. This sampling was completed earlier but at reduced scale because of reduced access to laboratories due to COVID-19. Planning is underway for the March 2021 RV Investigator voyage. This voyage will include krill deployment of AAPP BGC-Argo floats and collection of calibration samples in the southern seasonally ice-influenced Antarctic Circumpolar Current northwest of Prydz Bay. The design for the Krill Observational Moorings for Benthic Investigation (KOMBI) System was completed. Planning is well underway for the December 2020 RV Investigator voyage, SOLACE (Southern Ocean Carbon Export process study) and will involve deployment of AAPP BGC-Argo floats and collection of calibration samples. Discussion with phytoplankton physiologists, molecular biologists and biogeochemists to help shape the new proposed international BIOGEOSCAPES programme (<https://www.biogeoscapes.org/>) were held at the Ocean Sciences Meeting in San Diego, CA, in February 2020. Laboratory experiments examining the biological responses of primary producers to a range of environmental forcing (i.e., altered ocean conditions such as warming, nutrient supply and their interplay) are proceeding. The design of these experiments is unchanged, but the implementation of the studies has been delayed by about 3 months due to COVID-19 restrictions. Extending the lab-based environmental manipulation studies to the ocean using 1000l large volume mesocosms at sea to look at food web responses to simulation of altered Southern Ocean conditions is contingent on the SOLAS voyage going ahead as planned.

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004	The Nature and impacts of Southern Ocean change	30/06/2029

(4000 max)

Theme 2 consists of two projects: Oceans and Biogeochemistry. The Oceans project made good progress towards Milestone 004. Much of the work also contributes to Milestones 002 and 003. Highlights include: 1. Continental shelf circulation, water mass formation and ocean-ice interaction: ice-capable profiling floats have provided the first year-round, full-depth measurements of water properties on the Antarctic continental shelf. A new study shows that the challenge of positioning floats under sea ice can be overcome by using bathymetry data to constrain float trajectories, greatly increasing the value of under-ice float data (Wallace et al., 2020). The float data and model simulations are being used to describe changes in water masses, sea ice formation, and heat content over an annual cycle in the Mertz polynya (van Wijk et al.). Floats were deployed near the Totten Ice Shelf as part of a joint Japan-Australia study of ocean – ice shelf interaction; 2. Change in the deep Southern Ocean is being assessed using repeat ship measurements and a new array of deep Argo floats. A paper under review at Nature Geoscience identifies the physical mechanisms driving a recent rebound in salinity and density of Antarctic Bottom Water formed in the Ross Sea. The increased salinity reflects an increase in sea ice formation, resulting from a decrease of sea ice advection into the region, which is in turn driven by eastward wind anomalies linked to an unusual combination of positive SAM and strong El Niño; and 3. Dynamics of the Antarctic Circumpolar Current: Theory and idealised modelling work is providing new insights into standing meanders of the ACC and their role in the momentum balance of the current. A high-resolution numerical simulation has revealed the substantial influence of small-scale topography on the momentum balance of the ACC (Zhang et al., 2020). Analysis of a large field study of an ACC standing meander conducted in 2018 continues, with several PhD students and AAPP researchers using the data set to investigate how the meander influences internal waves and mixing, air-sea interaction, upwelling, and water mass variability. The recovery of a tall mooring was delayed by COVID-19 but is now scheduled for August 2020. The Biogeochemistry project appointed Dr Tyler Rohr (Carbon Biogeochemist) who commenced 1 March 2020. Highlights towards Milestone 004 include: 1. Southern Ocean carbon uptake and storage: The role of changing circulation on the magnitude of air-sea CO₂ fluxes has been investigated in several studies, including an analysis of the role of eddies in transporting carbon (Patel et al., 2020) and model studies of future ocean heat and carbon uptake and storage. AAPP is playing a leading role in developing the global array of biogeochemical floats (BGC-Argo). BGC floats will be deployed on two Southern Ocean voyages in the coming season. BGC postdoctoral fellow Tyler Rohr will participate in the voyage and collect samples for evaluation of the oxygen, pH, nitrate, chlorophyll and backscatter sensors, as part of a broader effort to examine ocean productivity and its contribution to the biological carbon pump. The recovery of the Southern Ocean Time Series (SOTS) mooring was delayed and is now rescheduled for August. In the meantime, considerable effort was invested in the quality control, assembly, and publication of multi-year records; and 2. Understanding of iron recycling and bioavailability from aerosol and in-ocean studies of oceanic microbial communities and particle transformation processes: A new Masters project will commence in July to study the long-term history of aerosol trace metal deposition to the subantarctic Southern Ocean via analysis of trace metals in sediment trap archive from SOTS.

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005	Two (2) yearly workplans	1/5/2021

(4000 max)

The first two yearly workplan is not due until May 2021 for the forward two years of the project, i.e., July 2021 – June 2023.

Where applicable, describe any project activities completed during the reporting period that are not captured in the table above: (5000 max)

Theme 1: The Ice Shelves project team has been working in collaboration with Prof Bernd Kulesa (Swansea University) to analyse geophysical data sets from the Sørtdal Glacier, to examine variability in surface meltwater processes. This will contribute to the key scientific aim of identifying how climate forcing impacts the ice shelf. The Ice Core Project Team has developed numerous outreach products to help streamline laboratory tours and communication for IMAS labs. This team has also undertaken a number of media activities: 1. Kiem, Vance et al., 2020. Article in The Australian; 2. J. B. Pedro. Million Year Ice Core: Australia's oldest ice core project. Australian National Antarctic Research Expeditions, ANARE Club – NSW Branch, mid-winter festival. Scheduled 27 June 2020; 3. Episode of ABC Foreign Correspondent "Atom Hunters" covered the recent Australian-US project quantifying past changes in the atmospheric oxidising capacity using Law Dome ice - <https://iview.abc.net.au/show/foreign-correspondent/series/2020/video/NC2026H008S00>

Theme 2: Members of the Biogeochemistry project team provided input into the Surface Ocean Carbon Atlas (SOCATv2020; www.socat.info) and the Global Ocean Data Analysis Product (GLODAPv2.2020, <https://www.glodap.info>) which were released in June 2020. These databases deliver the major in-situ observations used to quantify the ocean carbon sink, ocean acidification, evaluate ocean biogeochemical models and report to the UN SDG process. The delivery of data and quality control efforts have been possible through the AAPP partners (CSIRO, AAD, UTAS and IMOS) and Biogeochemistry project staff. Several members of the Biogeochemistry project have a lead role in delivering improved capacity for underway CO₂ measurements. This includes working with NOAA-AOML, USA, the Bjerknes Centre for Climate Research, Norway, and GEOMAR, Germany, to incorporate new technology and software in measurement systems that deliver most of the SOCAT data and are considered the world standard. The updated systems will lead to more robust and streamlined data collection and reporting.

Theme 3: The Sea Ice project developed COVID-19 impact assessments for deferred field programs and communicated these to our main logistics provider, the Australian Antarctic Division. The COVID-19 impacts on the 20/21 Antarctic field season are expected to cause significantly delay in progressing observation-based science projects in the initial 2-3 years of AAPP. Dr Hobbs was confirmed to Leadership Group of SOOS Southern Ocean Indian Sector (SOIS) Working Group in May 2020. Members of the sea ice project were significantly involved in the organisation of the SCAR2020 Open Science Conference (e.g., as session chairs) and have adopted the organisation of virtual meetings and sessions after the cancellation of the event by SCAR. Some Krill and Ecosystems project members presented the 2019 Enrich Voyage acoustic analysis and krill biomass estimates to CCAMLR WG ASAM. The project also contributed to the re-coding and re-parameterisation of Generalised Yield Model (krill assessment model).

Is the overall project proceeding in line with your project plan and grant agreement?

Yes overall, the project is proceeding as planned. However, there are some caveats in terms of milestone reporting. The ASCI funding is to be provided at a flat rate of \$5 million per annum over ten years and commenced on 1 July 2019. It was expected that the funding profile would subsequently be reviewed to ensure it aligned with the Australian Government's long term scientific

priorities. With the release of the Australian Antarctic Science Strategic Plan and the establishment of the Australian Antarctic Science Council (AASC) in April 2019 and the release of the planned implementation plan in late 2020 there should be more certainty in the July-December period of 2020. The increased planning certainty for 2021 will enable the AAPP work plans to be achieved, as well as complementing other government research investments and effectively supporting collaboration between research and business organisations. As acknowledgement by both parties that the initial funding allocation would need to be re-profiled, there is flexibility to vary the amounts of funding provided over the term of the agreement. The ASCI grant started in July 2019 and we are pleased to report 80% of planned staff over the entire AAPP contract period have been hired with 20 staff commenced by 30 June 2020. The staff costs are a large part of the ASCI budget and therefore there is a significant underspend in the 19/20 financial year. We are running theme workshops in August 2020 to review workplans, to identify and mitigate risks in current projects, and that they are proceeding in line with the grant agreement. Any gaps identified in the current workplans or changes to planned activities identified will be considered by the Program Leader and the Management Committee to ensure a holistic approach to addressing the objectives of the AAPP.

Identify any changes or anticipated issues.

Comment on any impacts on project timing and outcomes and how you expect to manage these. (5000 max)

The Australian Antarctic Science Strategic Plan was approved and released early 2020. The ASCI/AAPP project plans align with the new Australian Antarctic Science Strategic Plan. Parts of the ASCI science program also require logistics support and this support needs applications to and approval by various national providers. These include the Marine National Facility (MNF) and Australian Antarctic Science (AAS) program and has already affected the timeline for capital expenditure (deep Argo floats and air-sea flux experiment) and field activities in later years from MNF and now likely to be 2022-23. Future logistic support for the new ship RSV Nuyina and field programs in Antarctica have also experienced delays (construction, trial voyages mainly due to COVID-19) and the full consequences are unclear. The new ARC SRI's have been announced (ACEAS led by UTAS and SAEF led by Monash). These exciting initiatives also place demands on logistics in Antarctica both in the near-term and longer-term and likely to affect geographic locations for fieldwork from 2023/24. We are running theme workshops in August 2020 to review workplans, identify and mitigate risks issues from COVID-19 on field work and other issues described above. Any gaps identified in the current workplans or changes to planned activities identified will be considered by the Program Leader and the Management Committee to ensure a holistic approach to addressing the objectives of the AAPP.

Are there any planned events relating to the project that you are required to notify us about in accordance with your agreement? Provide details of the event including date, time, purpose and key stakeholders expected to attend. (5000 max)

It was anticipated that there will be a launch of the ASCI/AAPP during 2020, however the timing of this event is yet unknown due to COVID-19 restrictions. The AAPP logo has been finalised with the AAPP website nearing completion.

The previously reported international meeting in Hobart from 31 July-11 August, 2020 – 'SCAR2020 – Antarctic Science – Global Connections', has now been cancelled due to COVID-19.

The intended outcomes of the program are:

- **Continued scientific research activity in the Australian Antarctic Territory, aligned with the objectives of the *Australian Antarctic Science Strategic Plan* and the outcomes sought by the *Australian Antarctic Strategy and 20 Year Action Plan*.**

- **Employment and funding certainty for experts, students and early career researchers to strengthen Antarctic science capability in Australia.**

Outline the project outcomes achieved to date. (5000 max)

The AAPP science projects are aligned with the objectives of the current *Australian Antarctic Science Strategic Plan*.

The research undertaken in Theme 1 contributes to the *Australian Antarctic Science Strategic Plan* outcome of focusing the 'research effort to address the most pressing of our science needs, particularly around the role of Antarctica in the global climate system' and 'answering fundamental questions and advancing key national interests'. The research also contributes to the key research area of the Australian Antarctic science strategic plan released on 26 April 2020, ICE, OCEAN, ATMOSPHERE AND EARTH SYSTEMS "Understanding the role of Antarctica and the Southern Ocean on Australia and the World", particularly the topics of 1. High-latitude climate science; 2. Role of the East Antarctic ice sheet in global sea-level rise; 3. Interpreting past climate records to inform future climate understanding; and 4. Atmosphere and weather.

The research undertaken in Theme 2 directly addresses knowledge gaps identified in the Oceans and Marine Ice in the Southern Hemisphere theme of the *Australian Antarctic Science Strategic Plan*. Specifically, the project will identify and quantify drivers of change in the ocean inventory of heat, freshwater and carbon and in the circulation and ventilation of the Southern Ocean, including near the Antarctic margin where the ocean interacts with sea ice and floating ice shelves. This research is essential to address "the most pressing of our science needs, particularly around the role of Antarctica in the global climate system," as articulated in the *Australian Antarctic Science Strategic Plan*. The research strategy is directly aligned with the ASCI priority to "support research that aims to understand the role of the Antarctic region in the global climate system and the implications on marine ecosystems".

The research undertaken in Theme 3 aligns with the *Australian Antarctic Science Strategic Plan* by providing leadership and excellence in Antarctic science, conducting world-class scientific research consistent with national priorities, and undertaking a research effort to address the most pressing of our science needs, particularly around the role of sea ice in the global climate system and the importance of sea ice in structuring Antarctic marine ecosystems. Furthermore, the *Australian Antarctic Science Strategic Plan* commits Australia to set in place a comprehensive policy and scientific research approach to ensure the sustainable management of the Southern Ocean krill fishery. The planned Investigator voyage in 2021 is designed to address this commitment.

80% of hires (technical, professional and academic) have been completed with the majority of staff commencing in the 1st half of 2020. Of the 20 positions filled by 30 June 2020, 10 are female and 10 male.