ANTARCTIC CLIMATE & ECOSYSTEMS
COOPERATIVE RESEARCH CENTRE

2017/18 Annual Report

Australian Government
Department of the Environment and Energy
Australian Antarctic Division

ALFRED-WEGENER-INSTITUT
HELMHOLTZ-ZENTRUM FÜR POLAR- UND MEERESFORSCHUNG

Australian Government
Bureau of Meteorology

CSIRO

UNIVERSITY of TASMANIA

Australian Government
Department of the Environment and Energy

NIWA
Taihoro Nukurangi

Australian Government
Department of Industry and Science

Business Cooperative Research Centres Programme

Contents

Annual Report 2017-18

Antarctic Climate and Ecosystems Cooperative Research Centre
Private Bag 80
Hobart Tasmania 7001
Tel: +61 3 6226 7888
Email: enquires@acecrc.org.au
www.acecrc.org.au

1 Executive Summary

2 Achievements

Research and Collaboration

One of the great legacies of this nearly three-decade journey is the great value of cooperative human effort. The unincorporated joint venture model has provided a mechanism to build links between key institutions in Hobart and the best research organisations nationally and globally, including end users in government and industry. Through partnering, the ACE CRC has ensured that research capability is used most effectively and has become an important driver of the Tasmanian economy and a major contributor in establishing the city of Hobart as a global centre for Antarctic research. The research leadership contributed to the ACE CRC by all of the core partners, coupled with the investment in early career researchers, has delivered both excellent science outcomes and sustained capacity development in the sector. During the reporting period, 47 early career researchers, support staff and casual staff were employed by the ACE CRC with a further 51 (FTE) staff contributed by partners through in-kind arrangements.

As the ACE CRC enters into its final year of funding under the Australian Government's Cooperative Research Centres Programme, it is on track to deliver all its contracted milestones by 30 June 2019. Although some 2017/18 research milestones were only partly achieved in that year, all are expected to be completed in 2018/19.

A packed summer field season saw ACE CRC scientists from all seven research projects participating in important research activities in Antarctica and the Southern Ocean conducting research as part of the Australian Antarctic Program. During December 2017 and January 2018, a team of ACE CRC-led ice core researchers embarked on a deep field expedition to recover a new ice core from Mount Brown, inland of Davis research station. The core will provide a valuable reconstruction of the climate history of the Indian Ocean, and is expected to provide additional insights into climate variability in Australia over the last one to two millennia.

While drilling was underway at Mount Brown, scientists were continuing fieldwork on the nearby Sørsdal Glacier, as part of a major international collaboration investigating the role of surface melting in glacial fracturing. A team of geophysicists installed a number of seismometers to track water transport in the ice, and conducted thorough mapping of water on the glacier using airborne ground penetrating radar.

Another group of researchers participated in a successful ninth season of ICECAP, alongside scientists from the USA, UK and France. For the past decade, the international ICECAP consortium has been employing airborne instruments including lidar to produce a detailed map of the East Antarctica's ice sheet. This season saw the team focus on the critical ocean-ice threshold at locations near Casey research Station, including the Totten Glacier, the Moscow University Ice Shelf and the Shackleton Ice Shelf. They completed over 13-thousand kilometres of survey during ten flights from the Casey skiway.

In early January 2018, the *RV Investigator* embarked on a marine science voyage aimed at building on our understanding of the Southern Ocean in global climate

processes. The team had a number of science objectives for the voyage that included the deployment of 11 deep-water Argo floats near the Antarctic edge. These new data-collecting, autonomous ocean robots were successfuly released and are now floating freely in the Antarctic circumpolar current, providing real-time data to scientists on temperature and salinity at depths of up to 5,000 metres. Researchers also used this voyage to collect new oceanographic data along the SR3 transect, which runs north-south between the south coast of Tasmania and the coast of Antarctica at approximately 140°E. Preliminary results from the most recent transect show a surprising recovery in the salinity and density of Antarctic Bottom Water, reversing a 50-year trend of freshening.

Atmospheric scientists were also collaborating on a major United States-led project aimed at understanding the role of super-cooled clouds in the climate system. For weather forecasters and climate modelers, the super-cooled clouds over the Southern Ocean represent one of the largest uncertainties in the prediction of the future climate of the Southern Hemisphere. On voyages throughout the summer field season, the *RV Aurora Australia* and *RV Investigator* were equipped with an array of high-tech instruments, including lidar and microwave radiometers, for gathering information on the clouds. The shipborne observations were supported from the air by weather balloons and by a United States Gulfstream V research aircraft, owned by the US National Science Foundation. The data will feed into climate models to improve global weather and climate forecasts in the high southern latitudes and across the globe.

A second voyage of the *RV Investigator* in March 2018 took researchers south again to deploy a new mooring in the Southern Ocean Time Series (SOTS) facility. The SOTS moorings are part of Australia's Integrated Marine Observing System (IMOS), and comprise of a number of components including a deep ocean sediment trap mooring, a surface biogeochemistry mooring and an air-sea flux mooring. Technical problems with the meteorology and biogeochemistry mooring unfortunately prevented its deployment this season, however, the team on board were able to successfully recover and deploy sediment traps in the same area. The same voyage also accommodated an additional ACE-led biogeochemical project involving 20 Hobart, interstate and international scientists.

Commercialisation and Utilisation

As a public good CRC, the ACE CRC aims to make its research outputs widely and freely available, consistent with the terms of the Antarctic Treaty System to which Australia is a signatory.

The ACE CRC has pioneered ways to provide its information in a user-friendly format. This information has informed government policies and industry strategy in many areas. For example, the ACE CRC continues to play a key role helping inform policymakers, international climate negotiators and other stakeholders about the latest knowledge on climate change. For example, six ACE CRC researchers have been among those selected to contribute to the Sixth Assessment Report (AR6) of the Intergovernmental Panel on Climate Change (IPCC). These included Professor Nathan Bindoff, Professor Philip Boyd, Dr Andrew Constable, Dr Catia Domingues, Dr Rebecca Harris and Dr Jessica Melbourne-Thomas. The ACE CRC has contributed to three IPCC Asessment Reports in the past, which have formed the basis for the global strategy to address climate change. The AR6 report is expected to be completed in 2021 and published in 2022.

In addition to a busy field season, the ACE CRC participated in a variety of important outreach events, including an International Ice Charting meeting, the Marine Ecosystem Assessment for the Southern Ocean (MEASO18) Conference, a variety of educational events such as the Festival of Bright Ideas in Hobart, and briefings to politicians and representatives across all level of government.

The 18th Meeting of the International Ice Charting Working Group in September 2017 saw over 60 scientists, mariners, regulators and operational ice forecasters from 12 countries came together to discuss issues affecting sea ice and iceberg information for the maritime community with a focus on the Antarctic.

The Marine Ecosystem Assessment for the Southern Ocean (MEASO18) Conference in April 2018 brought together over 170 scientists and policy makers from 23 countries with representatives from fishing industry and environmental groups for a major conference focused on Southern Ocean ecosystems.

ACE CRC researchers have also continued to produce a steady output of high-profile publications in prestigious scientific journals. Examples include a mid-2017 publication in Nature showing that ice-free areas in Antarctica could expand by close to 25 per cent by 2100 and drastically change the biodiversity of the continent. Another notable publication in a high profile Nature paper revealed how the regional disappearance of fast ice and pack ice since the 1980s has triggered huge ice shelf disintegrations on the Antarctic Peninsula. A publication in Science Advances in November argued that the release of freshwater by Antarctic glaciers can create a positive feedback loop in which the release of freshwater into the ocean helps drive further melting

Education and Training

During the reporting period, 64.5 (FTE) students were involved in PhD studies related to the ACE CRC, including 9 commencing students. There were also 8 completions. Of the 8 PhD students that graduated during the reporting period, 3 are in post-doctoral positions at partner institutions. A further 5 graduated PhD students are in post-doctoral positions overseas. There have been strong employment outcomes for this year's PhD graduates, who continue to develop outstanding professional careers. All of these results are well above Commonwealth Agreement milestone targets for the year.

The ACE CRC also continued long-standing efforts to foster the career development of students and early career researchers. This included a voyage in January aboard the Japanese research ship Umitaka Maru, which has been surveying the Southern Ocean and investigating the role of zooplankton in the Antarctic food web. The voyage builds on a long-standing research collaboration between ACE CRC researchers and Japanese researchers at the Tokyo University of Marine Science and Techmology (TUMSAT) and the National Institute for Polar Research (NIPR). In another Japanese collaboration in early March, ACE CRC staff and students participated in Hokkaido University's bi-annual sea ice field course held on the frozen Lake Saroma in Hokkaido. The location, which freezes over during winter, provides an opportunity for young and emerging scientists to get their first taste of research on sea ice, at a fraction of the cost and time required to get to the Antarctic. The ACE CRC's Summer Internship program also attracted strong interest from undergraduate applicants. The program, now in its third and final year, provides students with the

opportunity to undertake an 8-12 week project working alongside ACE CRC researchers.

Awards and Special Commendations

Several awards and accolades were bestowed on ACE CRC personnel during the period. In August 2017, research by the ACE CRC into the vulnerability of the Totten glacier to melting was nominated for a Eureka Prize for Environmental Research. The team, led by Dr Steve Rintoul, has achieved a high public profile in recent years for their studies into the vulnerability of the Totten Glacier.

The ACE CRC Chair, Dr Katherine Woodthorpe, was acknowledged in the Queen's Birthday 2017 Honours List as an Officer of the Order of Australia for her contribution to Australia's innovation system.

Ecosystem modeller, Dr Jessica Melbourne-Thomas was named one of Science and Technology Australia's 30 STEM superstars and was a finalist in the Women's Agenda Leadership Awards.

Internally to the organisation, there is an annual "CEO Award for Excellence", which is awarded to staff who demonstrate most strongly the values of the organisation. There were two recipients of this award in 2017/18: Dr Sue Cook and Dr Tom Remenyi.

Staff appointments

During the reporting period, the ACE CRC recruited the following people:

Eva Cougnon	Ocean Modeller
Mao Mori	Ecological Modeller
Joanne Potts	Ecological Analyst
Robert Strzepek	Marine Microbial Physiologist
Chen Zhao	Coupled Ice Sheet Ocean Modeller

The ACE CRC Board appointed Mr Mark Kelleher as the new CEO following the resignation of Dr Tony Worby in August 2017. Mr Kelleher came to the role following three years as the ACE CRC's Deputy CEO and has many years experience in government and industry in CEO and other leadership roles.

There were no major capital costs for this reporting period.

There were no internal or external reviews of the organisation during the reporting period.

During the reporting period, the ACE CRC contributed to an important review by Mr Drew Clarke AO PSM FTSE of the governance of Australia's Antarctic Science Program. This 2017 review was commissioned by the Department of Environment and Energy to inform Year Two actions in the 2016 Australian Government's Antarctic Strategy and 20 Year Action Plan. The 2018 Government response to the Clarke review was supported by two budget measures in the 2018/19 Commonwealth budget to revamp Antarctic science funding and govenance. The Government committed to a number of recommendations including the creation of an Antarctic Science Council and provided a 10 year commitment to funding a

new Hobart-based Antarctic collaboration to commence on 1 July 2019 (after the expiry of the ACE CRC) and a 7 year commitment by the Australian Research Council Special Research Initiative to Excellence in Antarctic Science from 1 January 2020. These commitments, have been strongly welcomed by the ACE CRC research community, and provide considerable reassurance that Antarctic and Southern Ocean research collaborations will remain a key national research priority into the future. Ensuring a smooth wind-down will be the key focus for the ACE CRC during its final year of funding.

3 Risks and Impediments

The ACE CRC management team has developed an organisational risk register to capture the different risks to the ACE CRC and to the delivery of the ACE CRC milestones. The ACE CRC identified the inherent risks associated with business continuity, finances, reputation, governance, people and safety, environment and community, and project delivery, as well as mitigation measures and specific actions to reduce our risk profile.

The risk register was updated and discussed at Board meetings during the reporting period, with more detailed consideration and tracking of risks undertaken by the Budget, Audit and Risk Committee. The purpose of the register is to ensure careful management of risks throughout the life of the ACE CRC. Over the reporting period, the overall risk profile of the ACE CRC continued to improve, with the majority of risks are now at, or better than, target. The exception to this is the loss of key people; this risk is mitigated through close management of staff contract terms and career plans.

4 Impacts

No significant change has occurred during the reporting period that would require adjustment to the Impact Tool.

5 Performance against activities

The ACE CRC remains on track to deliver all its milestones by 30 June 2019. Several 2017/18 milestones were only partly achieved but are on track to be completed in 2018/19, without impacting other remaining milestones.

The ACE CRC project portfolio is managed at the level of seven discrete projects within two programs: 'Oceans and Cryosphere' and 'Carbon and Ecosystems'. The overall 'Oceans and Cryosphere' program targets key gaps in our understanding of ocean and cryosphere processes in the Southern Ocean and Antarctica, with the aim of informing an effective national response to the challenges of climate change. The overall 'Carbon and Ecosystems' program aims to deliver knowledge of drivers and changes in the Southern Ocean carbon cycle and ocean chemistry (iron and acidification), the critical responses of biota to environmental change (primary producers, krill, seabirds, Antarctic seals, whales), and assessments of current status, and future trends and impacts on key species and the ecosystem as a whole. As many of the critical knowledge gaps are found at the interface between domains (atmosphere, ocean, cryosphere, biogeochemical cycles and biosphere), all seven projects are designed to be well-integrated with each other. A detailed summary of the research activities at the project level is given below.

Research Project 1.1 The Southern Ocean in a Changing Climate

Project Summary

Research Project 1.1 is examining how and why physical and biogeochemical properties of the Southern Ocean are changing, as well as assessing the human contribution to the change.

The project had a highly successful year with a number of notable achievements including the completion of an oceanographic transect between Tasmania and Antarctica along the SR3 transect. Measurements collected during the voyage will be used to quantify physical and biogeochemical changes throughout the full ocean depth. Preliminary results show a surprising recovery in the salinity and density of Antarctic Bottom Water, reversing a 50-year trend of freshening. The project also deployed the first array of deep Argo floats in the Southern Ocean, in collaboration with Japan, France and the USA. The floats will provide year-round, full-depth measurements, allowing changes in the Southern Ocean to be tracked with unprecedented resolution.

The voyage included two other ACE CRC projects: measurements of trace elements and isotopes were collected as part of the international GEOTRACES program, and measurements were also made of cloud properties and aerosols as part of an international program. The cloud research is aimed at identifying the causes of a persistent bias in climate models and suggestions for model improvements.

The assessment of changes in temperature and salinity for the global ocean has been completed with major drivers of the changes identified. The assessment has been completed through a sequence of papers and special reports on ocean heat content and salinity change in the Southern Ocean and world ocean. New products have been created and include oxygen, temperature and salinity using a 4-D variational assessment and available electronically. This work is an extension on previous assessments and extends the record of the decline in oxygen content in the Southern Ocean to 2016. Ocean temperatures have also been assessed through a number of publications showing the rapid heat uptake of the Sub-Antarctic Mode Waters with the Indian sector being the largest contributor since 2004. The drivers of the long-term trend changes in temperature and salinity have been assessed through model simulations using ACCESS ocean model. The final assessment will be published in the IPCC Special Report on Oceans and Cryosphere in September 2019.

Another fieldwork highlight was the deployment of profiling floats in the Ross Sea, in a collaborative effort with the USA and New Zealand. Oceanographic profiles collected by the floats and ships will fill one of the largest holes in the Southern Ocean observing system and help quantify the strength and variability of the Ross Gyre.

The project published a number of important research papers during the reporting period, including seven papers in Nature or Science journals. Examples include a holistic assessment of the future of Antarctica under low- and high-emissions scenarios that underscores the urgency and long-term consequences of choices made in the next decade; a review of Southern Ocean dynamics that articulated a new conceptual model highlighting the global influence of local processes in the Southern Ocean; a demonstration that wind-driven changes in the upper ocean

can account for rapid warming of the southern hemisphere oceans in the last decade; identification of a feedback process by which input of meltwater from Antarctica can drive further melting of ice shelves while also inhibiting formation of Antarctic Bottom Water; a study of the unprecedented marine heat wave in the Tasman Sea; and a study showing how sea ice melt drives water mass transformations in the Southern Ocean.

Important work on detection and attribution of Southern Ocean changes took place during the reporting period, focusing on analysing climate models to better understand the processes of simulated change, and how imperfect models can be best utilised. This work has resulted in one paper in review and a further in preparation, with this work being presented at the Antarctic Frontiers conference in Hobart and the SCAR POLAR2018 conference in Switzerland. This work generated collaborations with colleagues at the National Center for Atmospheric Research (NCAR) in Boulder, USA and Institut Pierre Simon Laplace (IPSL) in Paris, France. Although there have been delays related to how best to progress in light of some model deficiencies, we are on track to publish peer-reviewed detection and attribution statement on Southern Ocean change by May 2019.

Project scientists have also devoted substantial effort to activities of interest to end users. Prof Nathan Bindoff was successfully nominated to be a Coordinating Lead Author of Chapter 5 on oceans and Dr Will Hobbs is a Contributing Author on the IPCC Special Report on the Ocean and Cryosphere in a Changing Climate. This report will also assess Southern Ocean Change and will be released in September 2019.

Substantial effort has also been devoted to outreach activities, including media, school visits and National Science Week activities. As one example, a variety of approaches have been used to communicate the key messages of the Nature paper on "Choosing the future of Antarctica," including a plenary panel discussion at a major international meeting; a short video that has been viewed more than 37,000 times; an article in the Conversation that has been read more than 15,000 times; and numerous interviews in the national and international media. Dr Will Hobbs and Prof Nathan Bindoff were also invited to present their work at a CCAMLR-sponsored meeting on future krill fisheries and will result in a CCAMLR report in October 2018.

Research Project 1.2 Ocean Forced Evolution of the Antarctic Ice Sheet

Research Project 1.2 is determining the sensitivity of the Antarctic ice sheet and ice shelves to changes in ocean heat flux and the potential contribution to sea level rise.

The project has reported a productive year of research and remains on target to achieve all research outputs. Notable achievements include a successful summer field season on the Totten Glacier accessing and downloading data from phase sensitive radars and GPS units at six locations to track ice motion and basal melt. These are the first measurements of basal melt rates of the Totten Glacier ever produced. Airborne geophysics surveys (ICECAP) were successfully conducted near several key outlet glaciers that included for the first-time air-based measurements of ocean temperature and bathymetry, with extensive surveys in the region of the Totten Glacier that are co-incident with surface instrument deployments and

provide the first direct connection linking ocean state and the basal melting of the ice shelf. The analysis of these data, together with ICECAP ocean float measurements, should provide the first direct observed link between ocean temperatures and the basal melting for the Totten Glacier.
Researchers made a key finding that wind is responsible for bringing warm water to Totten, causing the glacier to melt from below. This discovery has helped answer the question of what causes the Totten to flow faster in some years and to slow down in others. Climate change is expected to increase the intensity of winds over the Southern Ocean throughout the next century, and the new findings show that the Totten Glacier will probably respond to the changing winds. Upwelling can have big impacts around Antarctica, where the deep waters tend to be the warmest. Seismic surveys of the Totten proceeded in collaboration with the Antarctic Gateway Partnership and discovered that there was ocean beneath regions of the glacier that were previously thought to be grounded, which may help to explain recent periods of accelerated melting and flow.

At the Sørsdal Glacier, near Australia's Davis research station, ACE CRC researchers and Drs Sarah Thompson and Bernd Kulessa from Swansea University, undertook helicopter radar measurements to profile and map extensive sub-surface drainage features that were discovered last season. This was the first attempt to map how surface ponds can form and discharge, which can influence both the flow and calving of ice shelves, which are expected to increase as air temperature around Antarctica warms.

A successful annual maintenance visit to phase sensitive radars deployed on the Amery Ice Shelf achieved data retrieval with continued monitoring of these with fibre optical temperature strings.

Progress was made in ice-sheet modelling activities, with publication of a key paper incorporating the influence of the important ice laboratory experiments theory into a state-of-the-art numerical model (ISSM). These experiments show that the traditional method used by all ice sheet models to date of a simple flow enhancement can lead to significant deficiencies in solutions. Laboratory experiments will now proceed to examine the role of ice close to the pressure melting point on rheology and implications for flow. Several papers were submitted, or are in advanced state of preparation, examining the role of calving on ice shelf stability and links with grounded ice shelf stability.

The international collaborative model intercomparison project that examines ice shelf-ocean interaction (ISOMIP+) is continuing to examine how different models simulate this physics. Researchers at the ACECRC and partner organisations have contributed results and have published an initial paper that describes the experiment and are currently preparing a manuscript that examines this interaction in more detail.

Research Project 1.3 Sea Ice Processes and Change

Research Project 1.3 is aimed at improving understanding of the processes of sea ice growth and retreat to assess future changes in sea ice volume and extent and their impact on climate, biogeochemical cycling and marine ecosystems.

The project's fast ice satellite mapping and analysis continued to produce important outcomes and is on track to complete the analysis of change and variability in the circumpolar distribution of coastal fast ice for June 2019. Work on fast ice mapping was extended substantially in space and time, with the Totten region now completed, adding to coverage now across much of East Antarctica. Work is underway on mapping remaining subregions in special areas of interest, such as the Mertz Glacier. High-resolution numerical experiments incorporating the new fast ice information have provided key insights into sea-ice-ocean-ice sheet interaction processes. This included the publication of a high-profile Nature article (Massom et al, 2018) in June 2018 on the role of regional fast ice and pack ice loss in triggering catastrophic ice shelf disintegrations on the Antarctic Peninsula.

Strong progress was made toward production of the first estimate of East Antarctic sea ice volume at maximum extent. This included development of new techniques using satellite microwave scatterometer data to discriminate between sea ice types and use the scatterometer product as a proxy for large-scale sea ice thickness, based on comparison with in situ observations from the Weddell Sea. Work is ongoing to validate these results and to investigate the applicability of these techniques to East Antarctic sea ice.

Attribution of changes in sea ice is progressing well in collaboration with the Bureau of Meteorology and colleagues in ACE CRC Project R1.1. Considerable progress was made in deriving large-scale fields of sea ice motion and key kinematic parameters (convergence and divergence which greatly affect sea ice thickening and thickness) from time series of satellite synthetic aperture (SAR) and visible-thermal infrared imagery. This important activity is also benefitting from Dr Petra Heil's leadership of an International Space Science Institute working group on deriving sea ice volume from space, with a highly-successful meeting being held in Switzerland in June 2018.

Due to circumstances beyond the program's control, it was unable to meet the milestone as originally planned of carrying out a marginal ice zone (MIZ) experiment to quantify ice-ocean-atmosphere interactions at the time of maximum regional sea-ice extent. AAS proposals were successfully written and scored highly but could not be supported due to lack of the requisite marine science time in the Australian Antarctic Program. The program has refocussed the project to derive important new MIZ information from other sources, including data acquired by Dr Guy Williams on recent international cruises, as well as satellite detection. This approach will ensure the milestone is delivered by June 2019.

Work on merging the sea ice-ocean-ice shelf model to the atmosphere component of ACCESS 1.0 had to be postponed due to the departure of Dr Kusahara in February 2018. The work is on track with delivery expected by June 2019 without impact on other milestones.

Research Project 1.4 Antarctic Climate Variability of the Past 2,000 Years

Research Project 1.4 is using ice core records to reconstruct climate changes in the Antarctic region over recent millennia in order to characterise natural variability and extend the instrumental records of recent change.

During the reporting period, the project continued to work closely with the international PAGES2k initiative, which is studying past global changes of the last 2,000 years. The PAGES2k working groups made a number of important contributions towards syntheses of regional, continental and hemispheric climate studies, including a community-sourced database of temperature-sensitive proxy records (PAGES2k Consortium, 2017), Antarctic climate variability at regional and continental scales over the last 2,000 years (Stenni et al., 2017), and through a review of regional Antarctic snow accumulation over the past 1,000 years (Thomas et al., 2017). The Australian group continues to play an important role in the PAGES 2k project CLIVASH2k (Climate variability in Antarctica and Southern Hemisphere in the past 2,000 years) that aims improve our understanding of large scale modes of climate variability and the mechanisms and drivers of climate change in Antarctica, the sub-Antarctic and the wider Southern Hemisphere during the past 2,000 years, and in the data management and submission to the PAGES Iso2k working group to develop a global database of paleo-water isotopes covering the past two millennia.

Engagement with Dr Anthony Kiem from the University of Newcastle regarding hydrology work continued during the period. This collaborative work used the Law Dome ice core record to reconstruct pre-industrial streamflow in Eastern Australia over the past 1,000 years (Tozer et al., 2018). The streamflow reconstruction provides a better understanding of present infrastructure vulnerability in the context of past climate variability for eastern Australia. Dr Kiem and Dr Tessa Vance (ACE CRC) were also granted ARC funding towards a Discovery project to investigate 'Flooding in Australia - are we properly prepared for how bad it can get?'.

A major activity was the successful fieldwork at Mount Brown South (MBS), recovering a 295 metre deep ice core, 65 metres of shallow firn cores, a collection of samples from a 2 metre deep snow pit and completion of GPS and radar measurements. The MBS ice core processing is our highest priority work within the ACE CRC RP1.4 and sample cutting and analysis is well underway. Sample processing and analysis of one of the 25m shallow firn cores has been completed. Preliminary dating using seasonal varying analytes (e.g. water isotopes and trace ion chemistry) estimates this 25m firn core spans the period 2018 to 1971. This firn core provides ~47 years of ice core chemical and physical ice core measurements that can be calibrated against meteorological/instrumental records and will further enhance and contribute the value of ice core proxies for exploring climate processes and forcing, which is a key research priority identified to characterise natural variability and extend the instrumental records of recent change. Ice core sample processing and analysis of the 295m deep ice core is currently underway. The majority of analysis of key analytes will be completed by June 2019, however it is likely that the full quality-controlled records will be completed post-June 2019 by the Australian Antarctic Division.

On completion of all laboratory analysis, including data quality control of raw data, dating and subsequent interpretation, the project team will produce and publish the MBS ice core age model and accumulation record, as well as a temperature record using water isotope data. Exploratory analyses of instrumental overlap data and corresponding atmospheric modelling will be completed. Interpretation and synthesis papers will be published, including PAGES key data inputs of temperature, sea ice extent proxies and volcanic fluxes. Atmospheric modelling work identifying key climatic drivers, and initial interpretation of climate mode proxies and Southern Hemisphere (including Australian) climate teleconnections will be also produced.

Additionally, this project will leave legacy records of 1,000 years of climate information for many future research initiatives post-ACE CRC.

The Aurora Basin North ice core dating age scale is in final workup stage. Dating work is advancing on using existing dated volcanic records to match with ABN volcanic signals and investigating the use of correlation techniques. Sample analysis and processing has continued, and samples have been provided to national (CSIRO/ANSTO) and international (LSCE/CIC/AWI) partners for further measurements.

The project was pleased to welcome Dr Amy Hessl, a visiting Fullbright Scholar from West Virginia University. Dr Hessl will continue her work on the history of climate in southern Australia by collaborating with Dr Tessa Vance at the ACE CRC. Chelsea Long completed her undergraduate honours year at the University of Tasmania for 2017. Chelsea was awarded a first-class honours, for her class work and honours thesis entitled "Investigating the Potential for Volcanic Sulphate Aerosols to Increase the Flux of the Cosmogenic Radionuclide Beryllium-10 to Ice Cores in Law Dome, East Antarctica". Chelsea gained invaluable experience as a young researcher and has demonstrated her understanding of the processes by which climate, environmental and atmospheric signals are recorded in ice sheets, with subsequent laboratory experience revealing how these, often subtle, signals can be discerned.

A new appointment of Dr Joel Pedro has been made to investigate the detailed covariance study of EPICA Dome C temperature gradient and Law Dome sea salts spanning 19,000 to 6,000 years BP, and a reconstruction of westerlies over this period. The research is expected to reconstruct past changes in the intensity of the westerlies in the Indian to Australian sector of the Southern Ocean. The project addresses the ACE CRC milestone "provide improved constraints on the physical mechanisms responsible for periods of major change". The work will synthesise data from ice cores (EPICA Dome C and Law Dome) along with climate reanalysis data and GCM simulations.

Research Project 2.1 Carbon Uptake and Chemical Change

Research Project 2.1 is determining whether the Southern Ocean will continue to moderate climate change via uptake of atmospheric CO_2, quantifying regional and seasonal variations in the extent of ocean acidification, and examining iron supply as the limiting nutrient underpinning Southern Ocean productivity.

The project performed well in the reporting period with no significant risks to delivery of the milestones. Due to rescheduling and vessel change for the main part of the SR3 section (research milestone R2.1.3) to January/February 2018, some research publications and outcomes will be delivered in the first half of 2019, although all fieldwork was completed in the 2017-18 reporting period with all voyage objectives either achieved or exceeded. The CO_2 component is completed with a paper on changes along the SR3 section published (Conde Pardo et al., 2017). Another international synthesis publication with ACE CRC co-authors is in review and includes SR3 section data (Carter et al., submitted). SR3 section data are available through the Global Ocean Data Analysis Project (GLODAP) portal at the University of Bergen where ACE CRC staff are involved in the reference user group. Surface ocean CO_2 measurements along SR3 are available through the Surface Ocean CO_2 Atlas (SOCAT) portal and have been used in large synthesis publications involving ACE CRC staff to determine large scale inter-annual change in ocean carbon uptake for

the Southern Ocean (Landschutzer et al., 2015) and for an improved oceanic constraint for global carbon budgets as the ocean carbon uptake and atmospheric CO_2 increase determine the land sink (LeQuere et al., 2018). Data and research outputs from the iron component of SR3 will be synthesised, published and submitted to the GEOTRACES Data Assemble Centre in early 2019.
New perspectives built on carbon cycling by synthesizing high frequency automated observations using the Southern Ocean Times Series moorings milestone have been completed with several papers published and several submitted which summarise these new insights including:

- Despite the very deep mixed layers (~500 m) that occur in winter, net community production (NCP) is significant during this period and into early spring, accounting for ~30% of the annual NCP prior to the onset of stratification which starts about October 1 based on the heat flux changing sign from out to into the ocean (Weeding and Trull, 2014), and this appears to result from reduction of grazing in winter owing to the dilution of the zooplankton to phytoplankton ratio (Trull et al., 2018, in progress). These results suggest that future changes in CO_2 uptake in the SAZ are likely to be controlled as much by winter as summer conditions.
- While the pCO_2 seasonal cycle in the SAZ south of Australia as observed at SOTS has much lower amplitude than the strong drawdown that occurs in the iconic North Atlantic bloom at similar latitudes in the northern hemisphere, it also has much greater duration leading to a larger transfer of CO_2 into the ocean over the annual cycle (Shadwick et al., 2015). This result further emphasizes the importance of the Southern Ocean to carbon sequestration of both anthropogenic and pre-anthropogenic CO_2. This seasonal cycle may now be evolving in response to changing seasonal frontal movements and circulation, processes that also affect ocean acidification in south eastern Australian coastal waters (Conde-Pardo et al, 2018, in progress).
- The SAZ phytoplankton community is numerically dominated by very small cells, especially Phaeocystis species, with bio-volume approximately equally partitioned across diatoms, dinoflagellates, and ciliates. The system fully depletes silica seasonally yet manages to export organic carbon to depth (~1.1 g C m-2 yr -1) at levels similar to the global median (Eriksen et al, 2018). Thus, lack of silica does not appear to strongly limit export production and therefore natural increases in Fe fertilisation will be able to drive increased carbon sequestration by the biological pump.
- Decadal changes in air-sea CO_2 fluxes are now well recognised in the Southern Ocean (Landshutzer et al., 2015) from the assembly of many streams of surface ocean pCO_2 data including from SOTS, as published via the Surface Ocean Carbon Dioxide Atlas and used in Global Carbon Project carbon budgets (Le Quere et al., 2018). These changes include increased CO_2 outgassing from upwelling south of Australia as revealed by SR3 repeat sections over the life of the CRCs (Conde-Pardo et al., 2018).

Scientific findings have been transferred into outcomes for stakeholders, notably through the preparation of Position Analysis papers and deliver of Research Users Fora in Canberra to Government departments and agencies, plus a number of scientific outreach activities for local communities and schools. Project RP2.1 research findings are also relevant to the recent intergovernmental agreements establishing ocean acidity as one of seven targets for the United Nations Sustainable

Development Goal for the oceans, and as a headline climate indicator for the United Nations Framework Convention on Climate Change. There have been no technical issues or scientific impediments in the reporting period, and no proposed changes to future research directions in this centre funding for the ACE CRC (2014-2019).

Research Project 2.2 Biological Responses to Environmental Change

Research Project 2.2 is investigating how key Southern Ocean biota respond to multiple physical and chemical changes, such as warming, acidification and changes in sea ice. One of the fundamental questions addressed by the project is how climate change will affect the growth of key phytoplankton species. To understand this question, ACE CRC researchers have employed novel experimental methods for understanding the environmental conditions that influence the growth of phytoplankton, and how they might change during the coming decades. The project team has completed experiments on the growth response of key diatom species under projected ocean conditions for the year 2,100. Where past experiments on phytoplankton have tended to focus on the effect of changes in individual properties such as acidity or temperature, this study combined multiple drivers, including light, nutrients, carbon dioxide, temperature and iron, in order to get an understanding of how these drivers interact and of their combined effects on phytoplankton. Preliminary data analyses indicate that phytoplankton activity is likely to increase significantly, with phytoplankton in the sub-Antarctic Southern Ocean to grow at almost twice their current rate by 2,100. However, while some species are likely to benefit significantly, others are likely to suffer declines in productivity. Thus, it is still too early to make conclusions how phytoplankton communities (i.e., other diatom species, polar diatoms; other functional groups such as ubiquitous pico-eukaryotes) will change and how this will affect the broader structure of the ocean ecosystem. The experimental work has been complemented with a ship-based survey onboard *RV Investigator*. During the 2018 voyage, RP2.2 personnel measured phytoplankton iron-uptake and carbon export rates in the vicinity of the Southern Ocean Time Series (SOTS) site. Analyses and preliminary manuscript drafts are currently being completed.

Experiments on Antarctic krill tested the response of adult krill to ocean acidification (Ericson et al., submitted). This research showed that adult krill were able to survive, grow and mature when exposed to near-future ocean acidification (1,000 – 2,000 µatm pCO_2) for one year. The ability to maintain acid-base balance of the body fluid seems to be the key to the resilience of adult krill to ocean acidification, however, endogenous rhythms controlling metabolic rate, combined with food availability in the wild, may influence the vulnerability of krill to high pCO_2 in winter. Work on sea-ice ecosystem processes included a publication on observations of the role of winter sea ice for larval krill (Meyer et al., 2018). In contrast to a major Antarctic paradigm, the study demonstrated that the Antarctic pack-ice zone is a food-poor habitat but showed that complex under-ice habitats are vital for larval krill when water column productivity is limited by light, by providing structures that offer protection from predators and to collect organic material released from the ice. Further work included a meta-analysis of a comprehensive collation of historical sea-ice algal biomass data from Antarctic coastal locations resulting in a first constructed annual cycle of Antarctic fast-ice algal biomass and identifying key physical drivers in ice algal seasonal development (Meiners et al., submitted). In summary, despite some impediments to the project such as high krill mortality (in

2017), the project is on track with the expectation of full delivery within the next 10 months.

Research Project 2.3 Status and Trends in Ecosystems

Research Project 2.3 is assessing the current status and trends of physical habitat, individual species, and Southern Ocean ecosystems as a whole, and the likelihood of future states.

During the reporting period, the project progressed a marine ecosystem assessment for the Southern Ocean (MEASO) through the publication of the ACE CRC Position Analysis on Ecosystems and the running of the international conference MEASO 2018 in Hobart in May 2018. Interest in the conference by end-users of the outcomes of this project was high, with the fishing industry and environmental NGOs being major sponsors of the conference. The project contributed many leading papers and developments in assessment methods to the conference, including in statistical methodologies for assessing satellite data, methodologies for assessing tipping points in ecosystems, the use of ocean models to better understand the status and dynamics of pelagic habitats, such as for krill, and in the rapid assessment of mesopelagic assemblages based on ship-borne active acoustic measurements. The conference has been regarded a great success by the international community and work is now progressing to finalise the first MEASO to contribute to the IPCC and the Antarctic Treaty System by June 2019.

Also, a special issue publication arising from the Kerguelen Axis Marine Science voyage in 2016 is well underway with a number of papers now accepted for publication. The design of a circumpolar observing system has not progressed as fast as expected due to delays in finalising essential biological variables and in a number of analyses. Nevertheless, progress was made in this regard at the annual Science Steering Committee meeting of the Southern Ocean Observing System (SOOS) in May 2018. A workshop, co-led by ACE CRC scientists, was held in conjunction with that meeting to discuss modelling and assessments that could contribute to the design of the observing system. The workshop resulted in an action group in SOOS being established to progress the design of the circumpolar system of SOOS. This milestone will now be completed by 30 June 2019. Scientists within R2.3 have contributed to leading international studies on the use of sea ice habitats by krill, as well as in using acoustics to validate ecosystem models.

6 Education and Training

Education

The ACE CRC education program continues to be supported by, and provided through, the University of Tasmania's Institute for Marine and Antarctic Studies (IMAS). Students study a range of topics relevant to Antarctica and the Southern Ocean.

ACE CRC staff teach PhD students and also teach Honours programs and units in undergraduate courses, mostly to students taking science degrees, although a few undergraduates from other backgrounds (e.g., Arts) do enrol in first-year Antarctic studies units taught by IMAS.

During the reporting period, 64.5 (FTE) students were involved in PhD studies related to the ACE CRC, including 9 commencing students. There were also 8 completions and 3 PhD students withdrew during the reporting period. Of the 8 PhD students that graduated during the reporting period, 3 are in post-doctoral positions at partner institutions. A further 5 graduated PhD students are in post-doctoral positions overseas. There have been strong employment outcomes for this year's PhD graduates, who continue to develop outstanding professional careers.

The ACE CRC currently provides financial support to 14 PhD students through top-up scholarships, which are awarded on a competitive basis.

In total, 42 UTAS staff and 22 non-university staff including in-kind contributed staff were involved in PhD supervision.

A total of 86 students were admitted into the Bachelor of Marine and Antarctic Science during the reporting period with 14 completing. This course has superseded both the Bachelor of Antarctic Science and the Bachelor of Marine Science. During the reporting period, 4 undergraduate students completed the Bachelor of Antarctic Science with a further 1 continuing the Bachelor of Marine Science. A signficant number of these undergraduate students are expected to go on to higher degrees at UTAS.

Two Honours students commenced since July 2017 with two Honours students graduating during the reporting period (Chelsea Long and Abigail Smith). One of the graduated Honours students has since commenced a PhD.

A list of all ACE CRC PhD students, including commencement date, research program, project title, host research institution, student's country of origin and expected completion date, is provided in Appendix 2.

Three ACE CRC PhD students, Christine Weldrick, Jake Wallis and Stacey McCormack, were successful in applying for a sea ice field course through funding obtained from the Department of Foreign Affairs and Trade Australian-Japan Foundation. The Institute of Low Temperature Science (ILTS), an ACE CRC partner, hosts this course which involves a week of field training followed by a week of outreach activities in Hokkaido. The PhD students learned skills required for activities on the ice and techniques of sea-ice observations, including its physical properties and associated ecosystem.

Several PhD students attended the SCAR Open Science Conference 'Polar 2018' in Davos, Switzerland in June 2018 with several students awarded a SCAR travel grant to attend.

Concurrent with the IMAS and UTAS Graduate Research Office, the ACE CRC held a travel funding round and awarded four travel grants for students to either attend Polar 2018 Conference and/or the 7th SOLAS Summer School.

Furthermore, the free online marine and Antarctic science course which is run through the Open2Study program of Open Universities Australia, consisting of 37 short videos and four modules, attracted many students during the reporting period. Subject material covers the full spectrum of activity undertaken by IMAS. Prof Craig Johnson (IMAS) and Dr Jessica Melbourne-Thomas (AAD and ACE CRC) present the course. As of 5 September 2018, 24,269 students have taken the course; 109,393 videos have been watched; and 6,006 classroom posts have been made.

The ACE CRC has several structures in place for interaction with and between students. The 'ACE Chit Chat' series has been up and running since 7 June 2012 and has been managed by ACE CRC PhD students since September 2013. The 'ACE Chit Chat' sessions are held fortnightly and update staff and students on what other colleagues or students are currently working on, promote discussion, feedback and collaboration, and faciliate interaction with colleagues and students from different organisations. The weekly IMAS, CSIRO and AAD seminars also allow for students and researchers to have discussions and improve collaborations.

Summer Internship Program

The ACE CRC summer internship program was established in December 2015 with two internships offered each year, providing students with the opportunity to undertake an 8-12 week project alongside some the of world's leading scientists. The projects will be focused on Antarctic and Southern Ocean research and will be available on a competitive basis to undergraduate students interested in pursuing a career in Antarctic and/or marine science. For the final round of the program three projects were available.

Eleanor Haigh undertook one of the two R2.1 projects supervised by Drs Tom Trull, Peter Jansen and Christina Schallenberg (Biological controls on ocean productivity and CO_2 uptake at the Southern Ocean Time Series (SOTS)).

James Harley from the University of Melbourne undertook one of the two R2.1 projects supervised by Drs Tom Trull, Peter Jansen and Diana Davies (Biological controls on ocean productivity and CO_2 uptake at the Southern Ocean Time Series (SOTS): Developing bio-optical approaches to characterising ecosystem structure).

Nicola Ramm from the University of Tasmania undertook the R1.3 project supervised by Drs Alex Fraser and Rob Massom looking at radar backscatter as a proxy for Antarctic sea ice thickness.

The internship program allows for undergraduate students the opportunity to attend seminars, planning meetings, and gain experience working in a supportive, collegiate research environment.

Work experience

Several high school students were hosted by IMAS and the ACE CRC during the reporting period to experience all aspects of Antarctic and Marine research first-hand and also to better understand future career options within the Antarctic and Marine science field.

7 Engagement with Small and Medium Enterprises (SME)

In collaboration with SGS Economics and Planning, an SME as well as a formal ACE CRC 'Other Participant', the ACE CRC has successfully completed several projects by providing domain specific expertise both in a procedural or organisational context (such as understanding the scientific research sector and appropriate contacts, information or data sources), and in an academic context (reviewing existing literature; providing expert analysis or advice on climate change and its impacts).

The ACE CRC also continues to be an active contributor to the Tasmanian Polar Network, a group of businesses and scientific organisations based in Tasmania, that all have a common focus on supporting commercial and scientific activity in the Antarctic, sub-Antarctic and the Southern Ocean.

8 Commercialisation and Utilisation

The nature of ACE CRC research is the creation and utilisation via creative commons and open sourcing, and in general, consistent with the Antarctic Treaty, the approach is one of full sharing of research within the Antarctic research community.

The ACE CRC undertook a wide variety of activities to communicate our research outcomes to maximise awareness and uptake of our scientific work. Outreach activities have taken place with elected representative, policy makers and the public, as well as within the science community. These included briefings to politicians and representatives across all level of government; public lectures, school visits and science festivals; and regular review with key government departments such as Department of Environment and Energy, and Department of Industry, Innovation and Science, commercial participants, and ACE CRC's essential and other research participants.

During the reporting period, the ACE CRC hosted two key events, an international meeting and a conference, attended by 234 delegates.

The 18th Meeting of the International Ice Charting Working Group
In September 2017, over 60 scientists, mariners, regulators and operational ice forecasters from 12 countries came together to discuss issues affecting sea ice and iceberg information for the maritime community with a focus on the Antarctic. The IICWG was formed in 1999 to promote cooperation among the world's ice services on all matters concerning sea ice and iceberg. Its members regularly engage their users to ensure they are providing the best possible ice information, in the form of satellite images, charts, and forecasts, to help keep ships, their passengers, and the environment safe.

Marine Ecosystem Assessment for the Southern Ocean (MEASO18) Conference
In April 2018, over 170 scientists and policy makers from 23 countries came together with representatives from fishing industry and environmental groups for a major conference focused on Southern Ocean ecosystems. The 2018 Marine Ecosystem Assessment of the Southern Ocean (MEASO 2018) was co-hosted by the Australian Antarctic Division and the ACE CRC and was the first time that scientists studying all corners of the Southern Ocean have come together to try to develop a comprehensive picture of the status of its diverse marine life. The aim of the conference was to facilitate contributions from the Antarctic and Southern ocean marine science community to the 6th Assessment Review (AR6) of the IPCC, the IPCC Special Report on the Ocean and Cryosphere in a Changing Climate, and make a significant contribution to the development of Theme 6 Biology of the Southern Ocean Observing System (SOOS) and to update the SCAR Report on the Antarctic Climate Change and the Environment (ACCE).

The conference included a Policy Forum which brought together scientists, fishers, conservationists, policy-makers and managers to advise on what science is needed on ecosystem change and how it should be delivered to be most useful to

stakeholders and policy-makers. The forum will also consider how the best available science on ecosystem change can be used now in policy and management.

The outcomes of the Conference and Policy Forum will be provided to Australia's delegations to the Antarctic Treaty's Committee on Environmental Protection, the Scientific Committee for the Conservation of Antarctic Marine Living Resources, the International Whaling Commission's Scientific Committee and other organisations interested in the management and conservation of Southern Ocean ecosystems.

9 Intellectual property management

The ACE CRC is a public-good research centre focussed on the important role of Antarctica and the Southern Ocean in the global climate system, and on climate change and its impacts in the Antarctic, Australia and the world.

The value of the ACE CRC's IP can be measured by its social and environmental impact. As a public good CRC, the ACE CRC aims to make its research outputs widely and freely available consistent with the terms of the Antarctic Treaty System to which Australian is a signatory and with the conditions of participation within the Australian Antarctic Program. As such the ACE CRC does not seek commercial returns from its IP.

The ACE CRC IP comprises research outputs documented and published in peer-reviewed journals and public-ready documents such as position analyses and report cards. Data sets include those collected as part of Antarctic fieldwork as well as the outputs of climate models, such as sea-ice and ice-sheet models (and the sea-ice web-tool now with TPAC). These are all publicly available through repositories such as the Australian Antarctic Data Centre, Tasmanian Partnership for Advanced Computing, and the Integrated Marine Observing System. These data sets provide invaluable public-good assets for researchers now and in the future.

The ACE CRC presently archives its data and meta data with the Australian Antarctic Data Centre. This is a requirement of any Australian Antarctic research project to comply with Antarctic Treaty obligations.

The ACE CRC does not hold any patents in Australia or overseas.

10 Communications

The ACE CRC, manages its communications jointly with its partner organisations, as a major driver is partner representation.

It enjoyed another high-profile year in 2017-18, with a large number of articles in mainstream publications and broadcast outlets. As in previous years, the highest levels of media coverage were generated by interest in the maximum annual sea ice extent during September. The ACE CRC used its hosting of the International Ice Charting Working Group in September as an opportunity to issue a media release on Antarctic sea ice extent, which peaked at its lowest annual maximum extent on record during the week of the meeting. This new record, having come only two years after a record low winter extent, generated significant local and international media interest in the Working Group meeting and its objectives.

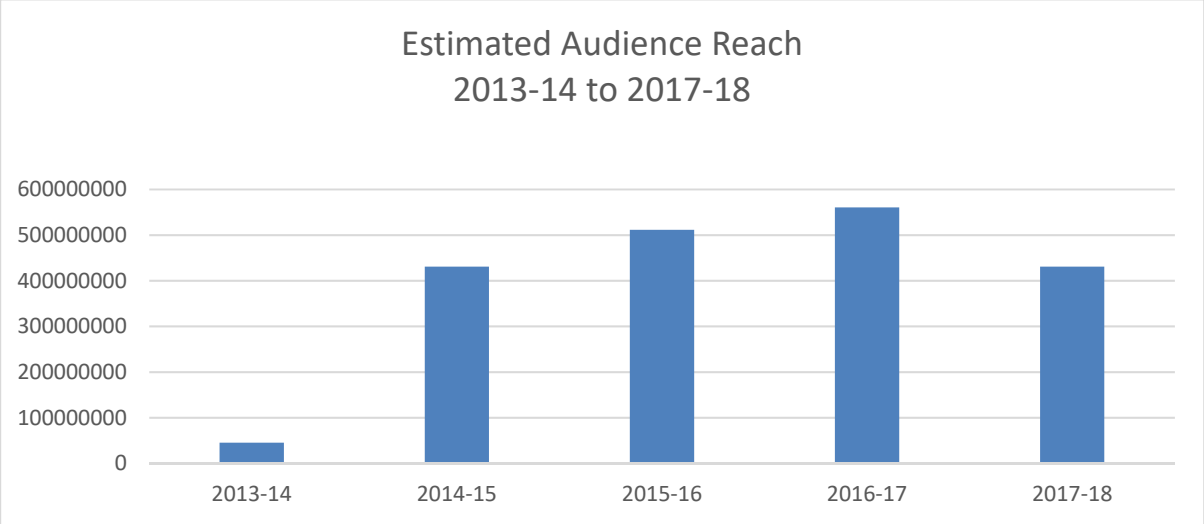
Preparation and management of the MEASO 2018 conference was another major communications activity during the period, which included management of web

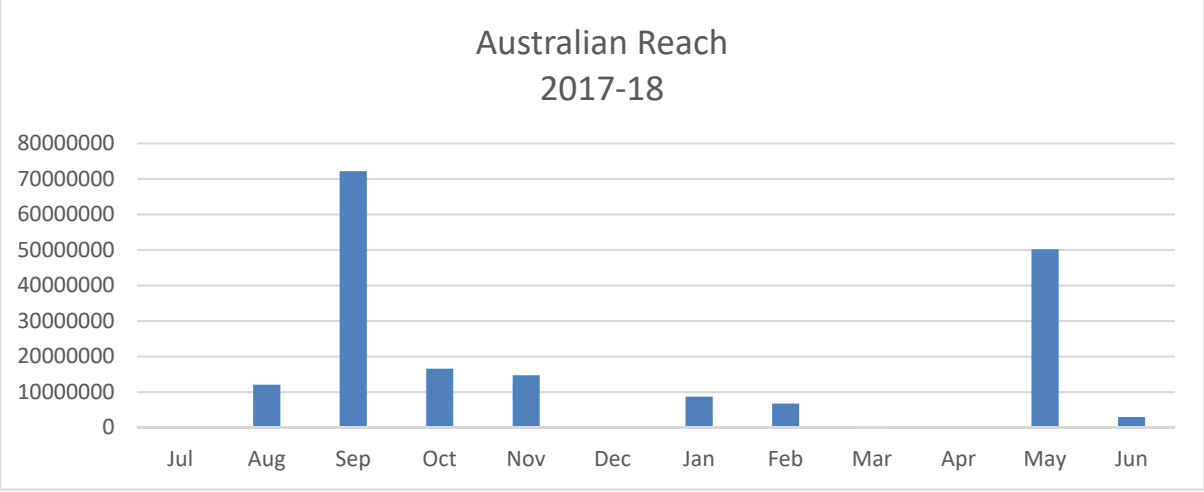
platforms, delegate communications, sponsor communications, and preparation of printed materials. The ACE CRC maintained a close and productive collaboration with AAD personnel around publicity for the conference. Media coverage was modest but satisfactory, with news and comment pieces appearing Fairfax, ABC PM, ABC Radio News and local television news. Engagement on social media was exceptional, with the #MEASO2018 hashtag generating roughly 250,000 views on Twitter and over 50 users involved in the discussion.

Significant activity during the period was devoted to preparations for the ACE CRC's 2018 Symposium on August 1. This included production of a 32-page booklet covering highlights from the past three decades of ACE CRC research.

Metrics

Audience reach figures provided below are from the Meltwater media monitoring service and are an estimate of the total potential audience for stories mentioning the ACE CRC and/or its staff members. Figures are calculated using an industry standard model based on publicly available circulation data. Overall estimated audience reach for the ACE CRC in 2017-18 was slightly below the previous year but remained above the average for the current term of the CRC.





Impact Analysis

An impact assessment of ACE CRC research was undertaken during the reporting period. Results were obtained using the Altmetric online platform, a reputation management and assessment tool now in wide use by the higher education sector. Altmetric provides a "comprehensive record of engagement with scholarly work, particularly that which takes place beyond the academy amongst a broader audience". To do this, the platform tracks a range of online sites and other sources for mentions (links or written references) to scholarly outputs. Sources of the attention include the mainstream media, public policy documents, social and academic networks, post-publication peer-review forums. The results of this analysis should be treated with some caution, since no guarantees can be made about the reliability of the measurement techniques, nor the completeness of the data set. For the purposes of a rough evaluation, however, the platform can be a useful method of analysis.

In broad terms, the analysis determined that the total volume of references to ACE CRC publications in news and social media have trended upward over the period of the current CRC, while policy document mentions have declined overall (see fig 1c). This downward trend for overall policy mentions is noteworthy and appears broadly in line with a similar trend for the University in Tasmania. Some potential explanations could include:

(a) statistical anomaly produced by a relatively low sample size;
(b) diminished focus on climate policy initiatives under the current government;
(c) other factors relating to methods of engagement at the policy level.

Exceptionally strong performance was observed in mentions-per-publication for ACE CRC publications. The total number of mentions-per-publication for news, social media and policy documents has generally trended upward over the period of the CRC and has been at least equal to, or above, other similar institutes housed within the University - and far in excess of the Australian average throughout the period.

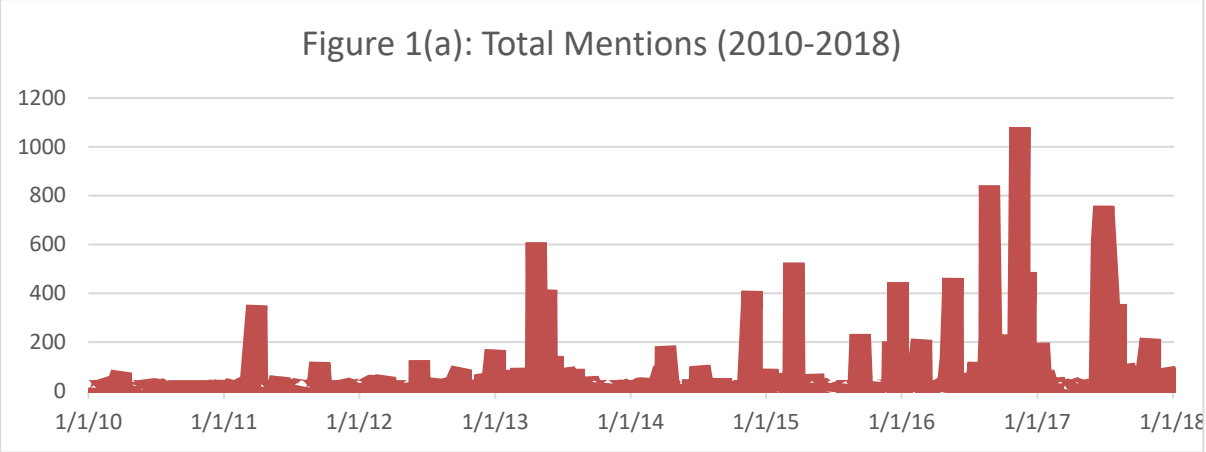


Figure 1(a): Total Mentions (2010-2018)
1200
1000
800
600
400
200
0
1/1/10
1/1/11
1/1/12
1/1/13
1/1/14
1/1/15
1/1/16
1/1/17
1/1/18

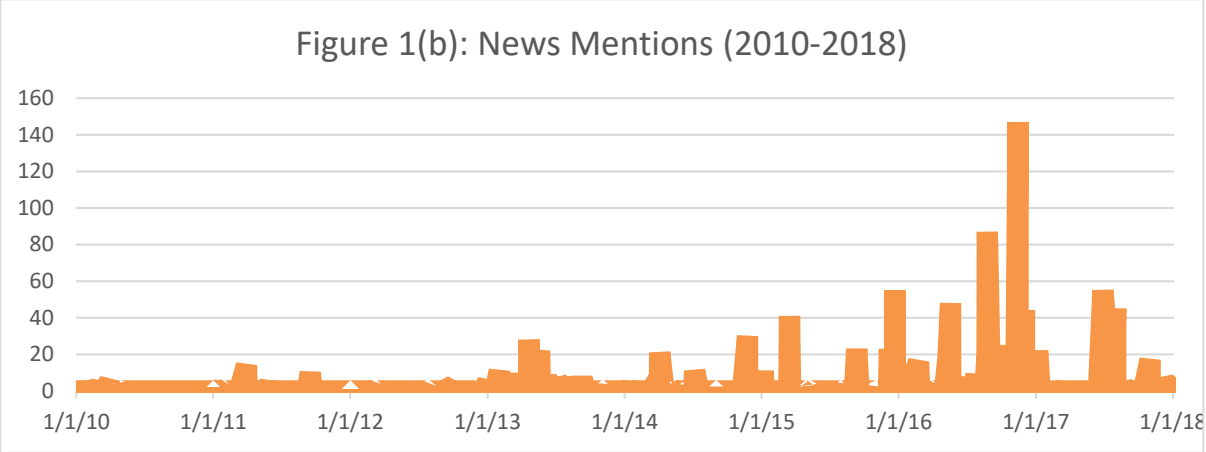


Figure 1(b): News Mentions (2010-2018)
160
140
120
100
80
60
40
20
0
1/1/10
1/1/11
1/1/12
1/1/13
1/1/14
1/1/15
1/1/16
1/1/17
1/1/18

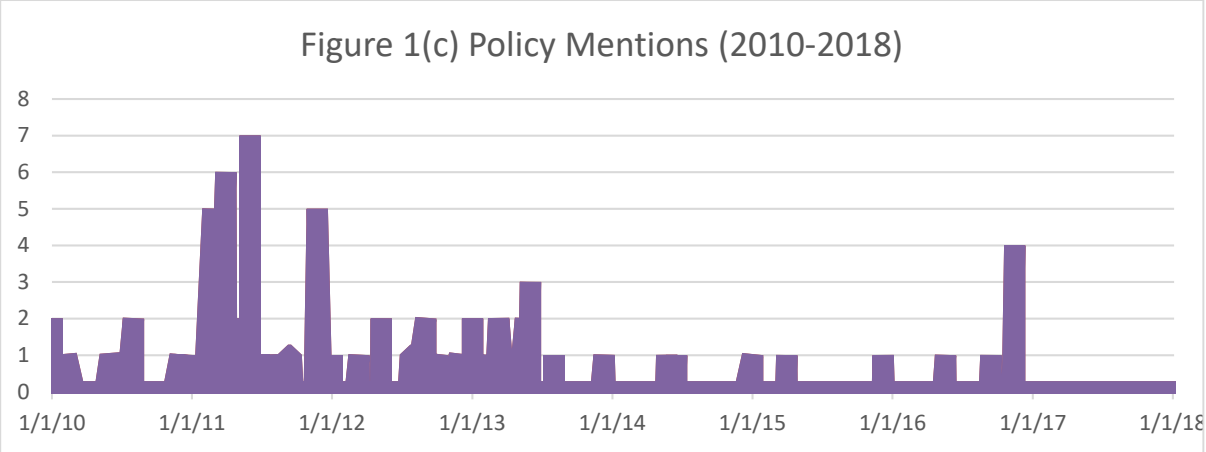


Figure 1(c) Policy Mentions (2010-2018)
8
7
6
5
4
3
2
1
0
1/1/10
1/1/11
1/1/12
1/1/13
1/1/14
1/1/15
1/1/16
1/1/17
1/1/18

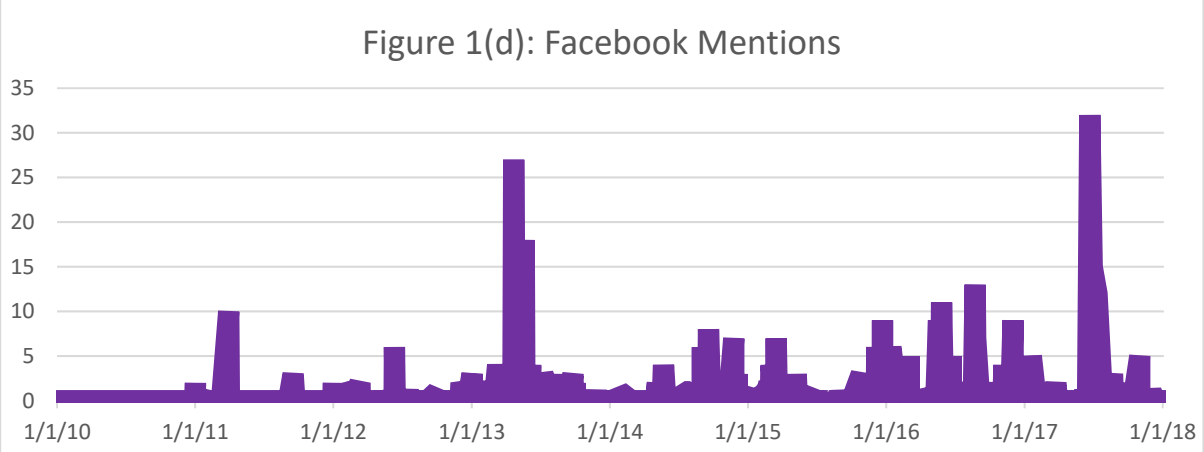


Figure 1(d): Facebook Mentions
35
30
25
20
15
10
5
0
1/1/10
1/1/11
1/1/12
1/1/13
1/1/14
1/1/15
1/1/16
1/1/17
1/1/18

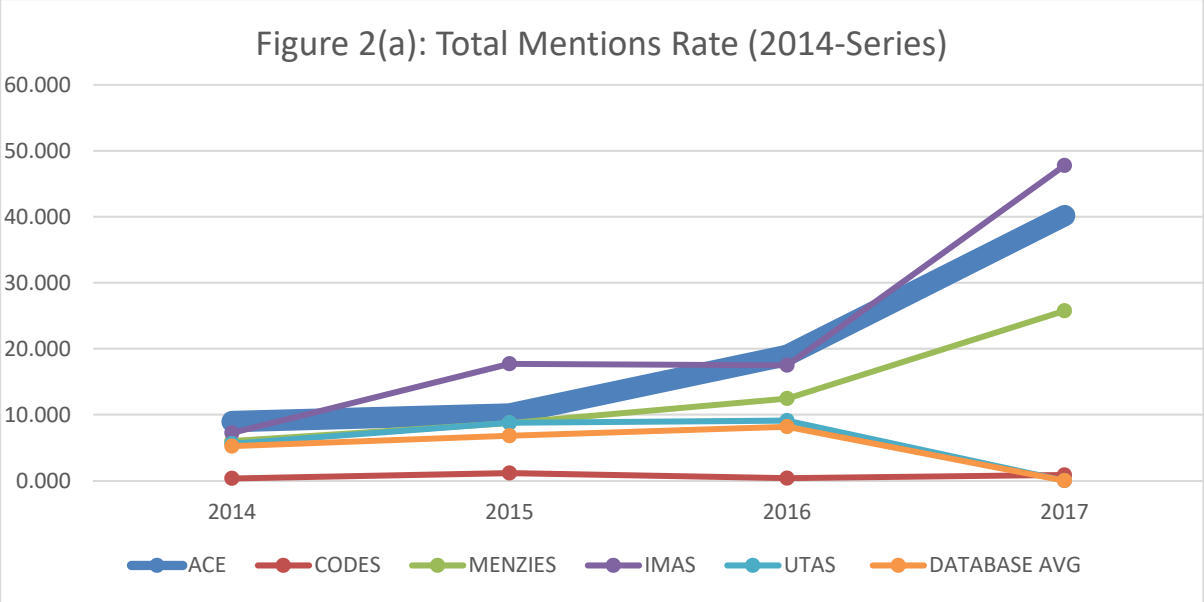


Figure 2(a): Total Mentions Rate (2014-Series)
60.000
50.000
40.000
30.000
20.000
10.000
0.000
2014
2015
2016
2017
ACE
CODES
MENZIES
IMAS
UTAS
DATABASE AVG

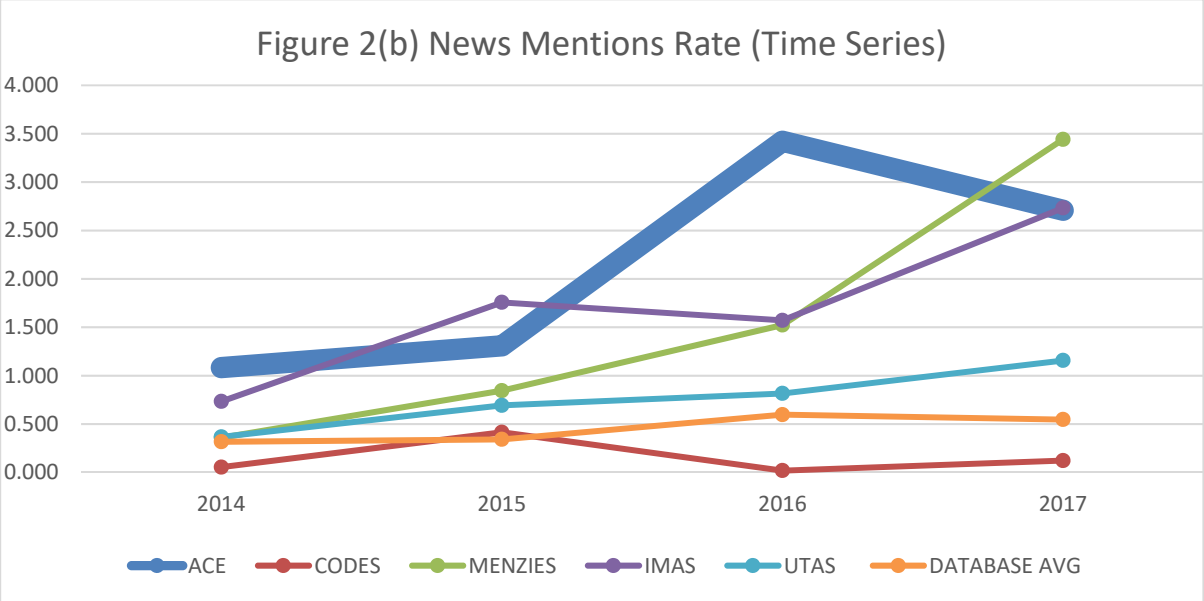


Figure 2(b) News Mentions Rate (Time Series)
4.000
3.500
3.000
2.500
2.000
1.500
1.000
0.500
0.000
2014
2015
2016
2017
ACE
CODES
MENZIES
IMAS
UTAS
DATABASE AVG

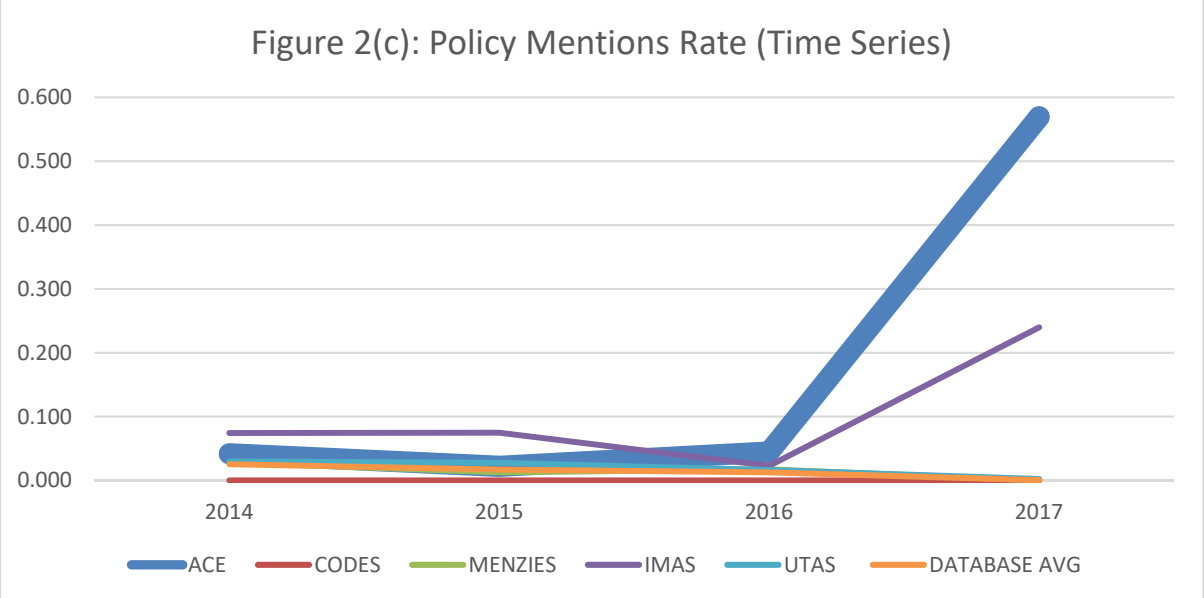


Figure 2(c): Policy Mentions Rate (Time Series)
0.600
0.500
0.400
0.300
0.200
0.100
0.000
2014
2015
2016
2017
ACE
CODES
MENZIES
IMAS
UTAS
DATABASE AVG

Selected Media Stories

Q&A: A trillion-ton iceberg is floating in the sea. Now what?, CNN, 13 July 2017

Sea Shepherd calls off Southern Ocean campaign against Japanese whaling, ABC PM, 29 August 2017

More climate scientists urgently needed for Australia, Sydney Morning Herald, 03 August 2017

Tasmanian researchers up for national gong at Eureka Prize ceremony, The Mercury, 30 August 2017

Experts puzzled by Antarctic sea ice melts, AAP, 26 September 2017

Antarctic ice melt baffles scientists, News Ltd, 27 September 2017

'Attacked from two sides': Antarctic sea ice hits another record low, Fairfax Media, 27 September 2017

Shipping risks rise as Antarctic ice hits record low, AFP, 27 September 2017

Homeward Bound: Women of science on Antarctic mission to save the planet, Kate Clarke, Sydney Morning Herald, 2 February 2018

'First hint' of a puzzling change in Southern Ocean revealed by CSIRO, Peter Hannam, Sydney Morning Herald, 19 February 2018

Collaborating with China in Antarctica, Indi Hodgson-Johnston, 19 February 2018

Antarctic sea ice shrinks for second-straight year, Phys.org, 02 March 2018

Sea ice around Antarctica is dwindling to near-record lows, Cosmos Magazine, 02 March 2018

More of Antarctica's Totten Glacier found to be floating, posing rising sea level threat, Cameron Gooley, ABC News, 20 March 2018

Sea levels could be rising faster than predicted due to new source of Antarctic ice melting, Josh Gabbatiss, The Independent, 19 April 2018

Scientists frustrated at lack of policy power to mitigate climate change, Felicity Ogilvie, ABC PM, 13 April 20178

Australia drought risk revealed in ice core analysis, Mike Foley, Queensland Country Life, 29 March 2018

Why science gets shut out of policy, Anthony Bergin, published across Fairfax outlets), 12 April 2018

Ocean Waves Triggering Antarctic Ice Shelf Collapse, Australasian Science, Jul 4

Large waves cause Antarctic ice shelves to collapse, Mind Food, Jun 14

Ocean waves in Antarctica can trigger ice shelf collapse, The New Zealand Herald, Jun 14

Ocean waves following sea ice loss trigger Antarctic ice shelf collapse, Voxy.co.nz, Jun 14

Waves trigger Antarctic ice shelf collapse, Business Scoop, Jun 14

Australia in Antarctica, ABC Radio National, Jul 27

Antarctica in 2070, The Examiner, Jun 15

What will Antarctica look like in 2070?, Monash University – LENS, Jun 14

High and low emissions scenarios for Antarctica, The Courier, Jun 15

Antarctica has lost 3 trillion tonnes of ice in 25 years. Time is running out for the frozen continent, Viw Magazine Australia, Jun 14

Ice core to shed light on Australian weather, Ntnews.com.au, May 145

Antarctic's climate history to be revealed by ice core sample from the deep, ABC Radio Australia, May 15

Ice core to shed light on Aust weather, Yahoo!, May 15

Thousand-year-old snowflakes to help climate change research, The Advertiser, May 15

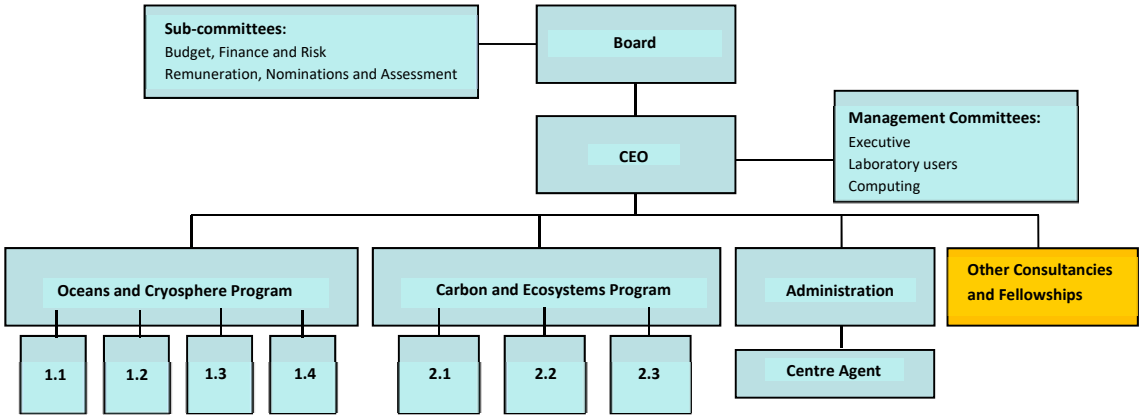
A 1000-year-old, 300m-long core drilled in Antarctica to reveal Australia's weather history, The West Australian, May 15

Australia drought risk revealed in ice core analysis, Queensland Country Life, Mar 29

11 Governance – board, committee and key staff

The ACE CRC is an unincorporated joint venture comprising of 7 core and 14 supporting partners, or 'other participants'. The participating organisations have a Centre Agent agreement with UTAS which provides that UTAS acts as the legal entity for the ACE CRC in respect of such matters as contracts, financial transactions and taxation. The seven Essential Participants are bound by the Participants Agreement, and the Other Participants Agreements set out the duties and commitments of the remaining 14 parties.

The governance and management structure of ACE CRC is as follows (as at 30 June 2018):



BOARD #

Katherine Woodthorpe – Chair
Tony Coleman – Independent
Gordon Hagart – Independent
Nick Gales – AAD
Sue Barrel – BoM
Tony Worby – CSIRO
Brigid Heywood – UTAS
Matt Cahill – Dept. of Environment & Energy
Mark Sayer – Tas Government
Mark Kelleher – Ex officio
Gwen Fenton – Ex officio
Wenneke ten Hout – Board Secretary

MANAGEMENT TEAM ~

Mark Kelleher – CEO
Wenneke ten Hout (0.8) – Business Manager
David Reilly – Public Affairs Manager
Claire Rutherford (0.4) – Admin

EXECUTIVE COMMITTEE #

Mark Kelleher – CEO (Chair)
David Reilly – Public Affairs Manager
Wenneke ten Hout – Exec Secretary/Education
Steve Rintoul – Program Leader
Tas van Ommen – Program Leader
Tom Trull – Program Leader
Andrew Constable – Program Leader
Nathan Bindoff – University liaison/Climate Futures
Ben Galton-Fenzi – Co-chair, Computing Committee

LAB USERS COMMITTEE #

Pamela Quayle – ACE Lab Manager (Chair)
Zanna Chase – Lab 304
Pier v/d Merwe – Lab 306
Cathryn Wynn-Edwards – Lab 308
Adam Treverrow – Lab 310
Andrew Moy – Lab 312D
Meredith Nation – Lab 312
Toby Bolton – IMAS Lab Manager

COMPUTING COMMITTEE #

Jason Roberts – Co-Chair
Ben Galton-Fenzi – Co-Chair
Alex Fraser - Secretary
Brendon Davey – TPAC
Chen Zhao – Student rep
UTAS IT representative

~ Meets weekly
^ Meets monthly
# Meets quarterly

The Board

The Board is constituted with a view to balancing the skills and experience of its members, and operates in accordance with the provisions of the Participants' Agreement.

The Board comprises (i) an independent Chair, (ii) one representative from each Australian Essential Participant, (iii) one representative of the Tasmanian Government, (iv) one representative of the Commonwealth Department of Environment and Energy, (v) two persons independent of the Participants and (iv) the CEO and the AAD Chief Scientist who are ex-officio members.

During the reporting period, Dr Sue Barrell commenced on the Board after the Bureau of Meteorology representative seat was vacated by Mr Graham Hawke late 2017. Mr Matt Cahill commenced on the Board after the Department of the Environment and Energy representative seat was vacated in 2017 by Mr Malcolm Thompson. Dr Andreas Schiller from the CSIRO was replaced on the ACE CRC Board by Dr Tony Worby late 2017.

Board meetings are held every quarter. During this reporting period, meetings were held on 4 August 2017, 9 November 2017 (including Annual General Meeting), 6 February 2018 and 8 May 2018.

Board Members (in alphabetical order)

Name	Role	Key Skills	Independent/ Organisation	Number of meetings
Dr Sue Barrell	Board Member	- High level national and international experience in science and policy - Science expertise in satellite meteorology, cold front dynamics and cloud band climatology	Bureau of Meteorology	2/4 (joined late 2017)
Mr Matt Cahill	Board Member	- High level management skills - Extensive experience in government and public policy	Department of Environment and Energy (Essential Participant)	3/4
Mr Tony Coleman	Board Member	- High level executive management experience in private enterprise - Financial audit, actuarial and risk management expertise - Commercial objectivity and independence from CRC participants	Independent	4/4

Name	Role	Key Skills	Independent/ Organisation	Number of meetings
Dr Gwen Fenton	Ex-Officio	- High level science planning and coordination experience - High level national and international experience in science and policy - Science expertise in stable isotope analysis of marine food webs	Australian Antarctic Division (Essential Participant)	3/4
Dr Nick Gales	Board Member	- High level national and international experience in science and policy - Science expertise in applied marine mammal conservation science	Australian Antarctic Division (Essential Participant)	3/4
Mr Gordon Hagart	Board Member	- Extensive experience in financial services including investment - Extensive experience in leadership and management at senior levels	Independent	4/4
Mr Graham Hawke	Board Member	- Extensive experience in research leadership and management at senior and institutional levels - Broad relevant domain expertise in climate and atmospheric science	Bureau of Meteorology (Essential Participant)	2/4 (replaced by Sue Barrell late 2017)
Prof Brigid Heywood	Board Member	- Extensive experience in research leadership and management at senior and institutional levels - Broad and extensive expertise in biological sciences	University of Tasmania (Essential Participant)	4/4

Name	Role	Key Skills	Independent/ Organisation	Number of meetings
Mr Mark Kelleher	Ex-officio	- High level executive management experience in both policy and operational roles in the public and private sector - Extensive experience in international business, investment and trade, tourism, and corporate governance and stakeholder management	ACE CRC	4/4
Mr Mark Sayer	Board Member	- High level executive management experience in both policy and operational roles in the public sector	Tasmanian Government (Other Participant)	3/4
Dr Andreas Schiller	Board Member	- High level national and international experience in science and policy - High level leadership and administrative experience - Science expertise in climate change, coupled-ocean atmosphere models, and ocean forecasting systems	Commonwealth Scientific and Industrial Research Organisation (Essential Participant)	2/4 (replaced by Tony Worby late 2017)
Dr Tony Worby	Board Member from early 2018/Ex-Officio	- High level leadership and administrative experience - Extensive experience in government and public policy - High relevant domain expertise in climate and marine science and policy	ACE CRC	3/4
Dr Katherine Woodthorpe	Chair	- High level management skills - High level Board skills - Broad experience on audit committees - Ventracor, Agenix and chaired the Audit Committee of Australian Cancer Technologies Ltd and Insearch	Independent	4/4

The Board has two sub-committees. The Budget, Audit and Risk (BAR) sub-committee includes 2 Board directors and an independent director as Chair of the committee. The primary objective of the Budget Audit and Risk committee is to monitor and provide effective supervision of management's financial and risk reporting processes, and review the adequacy of internal control systems to ensure accurate, timely and proper financial and risk reporting. The BAR committee met on 17 October 2017 and 9 April 2018. The committee reports to the Board as appropriate, through its Chair.

The Nominations, Remuneration and Assessment committee includes four members. It is Chaired by the ACE CRC Board Chair, and has a majority of independent members. The primary objective of the Nomination, Remuneration and Assessment Committee is to assist the Board in fulfilling its responsibilities by reviewing, advising and making recommendations to the Board on the matters pertaining to CEO and Board member remuneration, recruitment, performance appraisal, and succession planning. This committee met in July 2017 to review the CEO's KPIs.

Key Staff

Staff Member	Role	Organisation	% Time
Prof Nathan Bindoff	Project Leader – R1.1	ACE CRC/IMAS	50%
Dr Phillip Boyd	Project Leader – R2.2	ACE CRC/IMAS	20%
A/Prof Andrew Bowie	Project Leader – R2.1	ACE CRC/IMAS	50%
Prof Richard Coleman	Project Leader – R1.2	ACE CRC/IMAS	20%
Dr Andrew Constable	Program Leader – Carbon and Ecosystems	ACE CRC/AAD	65%
Dr Mark Curran	Project Leader – R1.4	ACE CRC/AAD	80%
Dr Ben Galton-Fenzi	Project Leader – R1.2	ACE CRC/AAD	80%
Dr So Kawaguchi	Project Leader – R2.2	ACE CRC/AAD	60%
Mr Mark Kelleher	CEO	ACE CRC	100%
Dr Rob Massom	Project Leader – R1.3	ACE CRC/AAD	80%
Dr Jessica Melbourne-Thomas	Project Leader – R2.3	ACE CRC/AAD	70%
Dr Klaus Meiners	Project Leader – R2.2	ACE CRC/AAD	80%
Mr David Reilly	Public Affairs Manager	ACE CRC	100%
Dr Stephen Rintoul	Program Leader – Oceans and Cryosphere	ACE CRC/CSIRO	50%
Ms Wenneke ten Hout	Business Manager	ACE CRC	80%
Prof Tom Trull	Program Leader – Carbon and Ecosystems	ACE CRC/CSIRO	50%
Dr Tas van Ommen	Program Leader – Oceans and Cryosphere	ACE CRC/AAD	60%

12 Participants

The commitment of the seven core partners to the ACE CRC remains strong. Our two international core partners, NIWA and AWI, are closely engaged with the ACE CRC.

ACE CRC participants during the reporting period

Participant's name	Participant type	ABN or ACN	Organisation type
Alfred Wegener Institute of Polar and Marine Research (AWI), Germany	Essential	NA	Government research institute
Australian Antarctic Division (AAD)	Essential	56 428 630 676	Government
Bureau of Meteorology (BoM)	Essential	92 637 533 532	Government
CSIRO Oceans and Atmosphere Flagship (O&A)	Essential	41 687 119 230	Government
Department of Environment and Energy	Essential	34 190 894 983	Government
National Institute of Water and Atmospheric Research Ltd (NIWA), New Zealand	Essential	NA	Government research institute
University of Tasmania (UTAS)	Essential	30 764 374 782	University
Centre for Polar Oceanography and Modelling (CPOM), University College London, UK	Other	NA	Research institute
Chinese Academy of Meteorological Science (CAMS)	Other	NA	Government research institute
Curtin University	Other	99 143 842 569	University

Participant's name	Participant type	ABN or ACN	Organisation type
First Institute of Oceanography (FIO), China	Other	NA	Government research institute
Institute of Low Temperature Science (ILTS), Hokkaido University, Japan	Other	NA	Research institute
Laboratoire d'Etudes en Géophysique et Océanographie Spatiales (LEGOS), France	Other	NA	Research institute
National Institute of Polar Research (NIPR), Japan	Other	NA	Government research institute
Old Dominion University	Other	NA	University
SGS Economics and Planning Pty Ltd	Other	25 007 437 729	Industry
Tokyo University of Marine Science and Technology (TUMSAT)	Other	NA	University
Tasmanian Government	Other	84 531 577 304	Government
Vrije Universiteit Brussels (VUB)	Other	NA	University
University of Texas at Austin, USA	Other	NA	University
University of Texas at San Antonio, USA	Other	NA	University

Changes to participants

There were no changes to participants during the reporting period.

13 Collaboration

ACE CRC is a collaborative joint venture of 21 national and international institutions. But beyond this formal organisational level partnership, collaboration is the basic model for all our research activities. In total, across its research program, the ACE CRC collaborates with 112 domestic and international organisations. Of these, there are 33 Australian, 3 New Zealand, 11 Asian, 21 North American, 1 South American, 41 European, and 2 Russian.

Of the 33 domestic collaborations, there are 7 Australian Government Institutions, 7 State Government Institutions, 13 universities, 1 industry/private sector, and 5 others.

Of the 79 international collaborators, there are 43 universities, 1 from industry/private sector, and 35 research institutions/organisations.

14 Financial Management

The ACE CRC completed the 2017-18 financial year with a cash balance of $1,523k. This reflects the deferral of $300k of capital equipment purchases into the 2018-19 financial year, and rescheduling of the SOTS voyage to August 2018 together with remaining contingency funds. The overall five-year programme remains on track in respect of milestone delivery.

Table 1

	Totals for 2017-18				Projected Totals for 5 years			
	Actual	**Agr'mt**	**Diff**	**%Diff**	**Actual/Proj**	**Agr'mt**	**Diff**	**%Diff**
Employee Expenses	4,075	3,245	830	26	18,371	16,642	1,729	10
Supplier Expenses	1,127	1,090	37	3	5,838	7,680	-1,842	-24
Capital	640	112	528	471	1,726	973	753	77
Other Expenses	0	553	-553	-100	419	753	-334	-44
TOTAL EXPENSES	5,842	5,000	842	17	26,354	26,048	306	1

The variations in expenses in 2017-18 were due mainly to deferral of $648k of capital equipment from the 2016-17 financial year, with the most significant component of this being deferral of $312k purchases of Argo floats (all this equipment is now classified as capital compared some categorised as expenses in the original budget) in order to secure the most recent software update. Interest and other income transferred from external funds have provided the basis for additional contract extensions for staff which provided improved milestone outcomes. The variation in other expenses was due to not needing to repay an overdraft facility as this was not needed in earlier years as originally anticipated due to cash management actions taken in the first three years.

Projected 5 year totals show that additional external and interest income totalling $1,354k, along with $375k in net savings in supplier/capital expenses underpin a number of contract extensions for research staff, reflected in the forecast employee expenses variance of $1,729k, that will support improved delivery of program milestones.

Staff and non-staff contributions from participants were on track to the amount committed in the budget, apart from the following:

Participants	Table 1(a) Number (FTE) of Staff in-kind Contributions	
	Amount Contributed (FTE)	Amount Committed (FTE)
Australian Antarctic Division	20.8	28.6
Bureau of Meteorology	0.7	0.5
Dept of Environment and Energy	0.1	0.2
CSIRO	5.9	3.5
FIO	3.2	3.0
SGS Economics and Planning Pty Ltd	0.1	0.2
Vrije Universiteit Brussel (VUB)	1.5	0.0

Participants	Table 1(b) Non-staff in-kind Contributions	
	Amount Contributed ($'000)	Amount Committed ($'000)
Australian Antarctic Division	3,125	3,650
CSIRO	8,656	200
First Institute of Oceanography (FIO)	3,250	2,750
Institute of Low Temperature Science (ILTS)	65	35
Tokyo University of Marine Science and Technology (TUMSAT)	80	120

Shortfalls in staff in-kind contributions were relatively minor and did not impact the program or objectives of the ACE CRC. Shortfalls in AAD were partly offset by additional CSIRO and VUB contributions.

The large CSIRO variance in non-staff contributions reflects an additional voyage provided on the *RV Investigator,* carried over from not being able to be conducted on the *RV Aurora Australis* the previous year.

For the Research Program overall, the variations in contributions in 2017-18 supported stronger delivery of programme milestones.

Research Program	Total Expenditure ($'000)	Amount Budgeted ($'000)
Research Program 1:		
Cash	3,750	2,889
Non-Staff in-kind	17,967	9,427
In-kind Staff (FTE)	32.60	33.40
Research Program 2:		
Cash	2,092	2,111
Non-Staff in-kind	995	1,115
In-kind Staff	18.47	21.50

Additonal Requirements

CRC future plans and transition arrangements

The current funding for the ACE CRC concludes on 30 June 2019. Recent changes in CRC guidelines preclude a rebid for funding under this mechanism.

The Department of Environment and Energy commissioned a review of the Australian Government's Antarctic Science governance in 2017. The Government response to the review was released in June 2018.

The Commonwealth Government announced new Antarctic science funding in the May 2018 budget of $13M per year. This funding will be applied in two components:

- The Australian Research Council's Special Research Initiative in Excellence in Antarctic Science will fund a total of $56M over 7 years; and
- The Department of Industry, Innovation and Science Antarctic Science Collaboration Initiative (ASCI) will fund a total of $50M over 10 years.

The Commonwealth Government recognised strengthening Australia's national Antarctic interests and Hobart's role as an Antarctic hub and research city by providing funding certainty for Australia's Antarctic Science Program.

While the ACE CRC will cease operations on 30 June 2019, the Government has provided long term funding certainty for collaborative Antarctic science. Decisions on the manner in which the new funding programs will function are being discussed in government and with key stakeholders and are expected to be finalised over the next 6 months.

Performance review

In July 2016, the Department of Industry, Innovation and Science released revised Programme Guidelines for the CRC Programme. In line with the Department's efforts to streamline administrative processes, and in accordance with Part Nine of the revised guidelines, CRC Performance Reviews were no longer required.

Other activities

Externally Funded Research

The ACE CRC continues to undertake a number of externally funded research projects, primarily in the area of fine-scale climate modelling and analysis.

Wine Australia – Australia's wine future: Adapting to short-term climate variability and long-term climate change: This project is funded by the Australian Grape and Wine Authority; commencing 1 July 2016 it is to complete by 30 June 2019. The project provides short-term climate variability, as well as trends in climate indices for the near and mid-term scales, in an accessible and usable form to grape growers and wine makers across Australia. The industry will have access to fine-scaled climate information required to identify the most appropriate adaptation response within each region to maintain grape yield, value and wine quality into the future.

Climate Change and Bushfire Research Initiative: This project was funded by the Commonwealth Department of the Environment and Energy (NESP) through emerging priorites funding and commenced on 1 December 2016 until 30 June 2018 and is an extension to the Tasmanian Wilderness World Heritage Area (TWWHA) project. This project developed high priority tools and research products to enable protection of the TWWHA from adverse impacts of wildfire. Project activities include research into the environmental impact of a range of firefighting chemicals in different environments along with their effectiveness as fire control agents in the TWWHA, including the environmental cost-benefit of using chemical fire retardants in the TWWHA. Research into the extent to which reduced negative impacts of firefighting chemical use can be achieved by providing guidance on situations where their use is or is not appropriate. The outcome provides management tools to enable the Tasmanian Government to protect the values of the TWWHA through changing their fire regimes.

High Resolution Reanalysis for Tasmania project: This project is funded through the Tasmanian Department of Police and Emergency Management and will generate a reanalysis dataset for Tasmania at 1.5km grid spacing with hourly time steps for a 25-year period, producing a high-resolution meteorological and climatological dataset to inform emergency management and disaster risk activities in Tasmania. The Bureau of Meteorology (BoM) has agreed to produce the reanalysis for Tasmania for ACE CRC, forming part of a wider project that will generate a nationwide Australian reanalysis product at a lower 12 km resolution. In the first phase of the project (Stage 1), the Bureau of Meteorology will provide a 5-year high-resolution NWP climatology for Tasmania at a spatial resolution of about 5 km and at an hourly time step. The second stage of the project will produce a 25-year high-resolution reanalysis at 1.5 km resolution. The project is now in phase 3 to deliver the remainder of the full 25 year high-resolution reanalysis dataset and to complete reporting and stakeholder engagement. Project partners will evaluate the dataset, both at the broad scale

and for specific sub-regions and time periods in considerable detail to ensure the quality of the data, with the resulting approximately 70 terabytes of data stored by TPAC. Partners will engage with stakeholders to highlight the implications of the results for emergency management in Tasmania. On completion, project and technical reports will be presented, and peer-review journal articles prepared.

An assesment of the viability of prescribed burning as a management tool under a changing climate project: This project is also funded through the Tasmanian Department of Police and Emergency Management State Emergency Services and will provide a greater understanding of changing fuel loads and ability to plan for changing vegetation patterns in the future. The project commenced in March 2018 and will conclude early 2019. On conclusion of the project manuscripts will be submitted to peer reviewed journals and a workshop will be held with key stakeholders.

Climate Analysis and Forecast Ensemble System (CAFE) – creating terciles of CSIRO CAFE model outputs: This project is funded through the CSIRO between February 2018 and June 2019. This project involved downloading forecasts from the CSIRO CAFE system and perform calculations of rainfall terciles in each of those forecasts to enable improved risk management of Hydro Tasmania's physical and financial position through better alignment of its contact position, future generation capability and financial rainfall hedge portfolio.

Modelling coincident extreme weather events under Tasmania's future climate project: This project is funded through the Tasmanian State Government Climate Change Office from March 2018 to February 2019. The project has three objectives: to increase our understanding and awareness of the current likelihood and impact of the highest priority coincident extreme events in Tasmania; to better understand how the frequency and impact of coincident extremen events may change in the future; and to inform state and local government, industries and communities so as to enable them to build their capacity to prepare for and respond to coincident extreme events. The project will deliver a technical report containing key findings on coincident events in the future climate and a workshop to communicate these key findings to key stakeholders.

Review of climate science – research gaps and opportunities in the Tasmanian context project: This project was funded by the Tasmanian State Government Climate Change Office and the ACE CRC from June 2017-Dec 2017. Agtrans Pty Ltd was appointed to undertake the study on identifying the economic benefits of the Climate Futures of Tasmania work. The report findings concluded that the investment in the Climate Futures of Tasmania initiative produced a net benefit of between $21.5 million and $86.5 million from a total investment of $16.4 million, and a benefit-cost ratio of between 1.3 and 5.3 to 1.

Mesopelagic Southern Ocean Prey and Predators (MESOPP) project: The MESOPP project is a collaboration between AAD, UTAS and various other international collaborators. The underlying concept of MESOPP is the creation of the collaborative network and associated e-infrastructure (marine ecosystem information system) between European and Australian research teams/institutes sharing similar interests in the Southern Ocean and Antarctica, its marine ecosystem functioning and the rapid changes occurring with the climate warming and the exploitation of marine

resources. The project is funded through the European Union and is due to be completed mid-2019.

Flooding in Australia: are we properly prepared for how bad it can get? project: Together with the University of Newcastle, this project will use novel insights from 2,000 years of climate reconstructions to generate new knowledge about: (i) how bad flooding can get and (ii) what causes flood frequency to change over time. A decision making framework that allows for all the uncertainties associated with managing floods will also be developed. This innovative and multidisciplinary approach will provide a critical evaluation of the accuracy of existing flood estimates – and also the reliability of infrastructure and policy based on those estimates.

During the reporting period, one PhD student was awarded an ACE CRC top-up with the research topic of 'Understanding Current and Future Impacts of Extreme Heat Events on the Health of Vulnerable Tasmanians'. This PhD will attempt to quantify the health, social and emergency response impacts of heatwaves in the Tasmanian context. Using a mix of qualitative and quantitative methods, the project will utilise a variety of available health service data (including ambulance caseload, emergency hospital admission, coroner data, symptom data from AirRater), using recent heatwave events in Tasmania as case studies as well as any significant heatwave that occurs during the course of the research. Using climate data available from the Climate Futures Tasmania project, the project will then attempt to project these impacts into the future, developing a model that can predict the health and welfare impacts on vulnerable communities in Tasmania from heatwave.

During the reporting period, these projects and other related concluded projects published 7 articles in scholarly refereed journals and 2 reports (see below).

Articles in scholarly refereed journals

Harris, R.M.B., Remenyi, T., Fox-Hughes, P., Love, P. and Bindoff, N.L. (2018). "Exploring the future of fuel loads in Tasmania, Australia: Shifts in vegetation in response to changing fire weather, productivity, and fire frequency." Forests **9**(4).

Latham, T., White, C.J. and Remenyi, T.A. (2018). "The relationship between irrigation-induced electrical loads and antecedent weather conditions in Tasmania, Australia." Irrigation Science **36**(3): 167-178.

Mantegna, G.A., White, C.J., Remenyi, T.A., Corney, S.P. and Fox-Hughes, P. (2017). "Simulating sub-daily Intensity-Frequency-Duration curves in Australia using a dynamical high-resolution regional climate model." Journal of Hydrology **554**: 277-291.

Ramm, T.D., Graham, S., White, C.J. and Watson, C.S. (2017). "Advancing values-based approaches to climate change adaptation: A case study from Australia." Environmental Science and Policy **76**: 113-123.

Ramm, T.D., Watson, C.S. and White, C.J. (2018). "Describing adaptation tipping points in coastal flood risk management." Computers, Environment and Urban Systems **69**: 74-86.

Rumm, A., Foeckler, F., Dziock, F., Ilg, C., Scholz, M., Harris Rebecca, M.B. and Gerisch, M. (2018). "Shifts in mollusc traits following floodplain reconnection: Testing the response of functional diversity components." Freshwater Biology **63**(6): 505-517.

Tozer, C.R., Kiem, A.S., Vance, T.R., Roberts, J.L., Curran, M.A.J. and Moy, A.D. (2018). "Reconstructing pre-instrumental streamflow in Eastern Australia using a water balance approach." Journal of Hydrology **558**: 632-646.

Reports

Bindoff N.L., Love P.T., Grose M.R., Harris R.M.B., Remenyi T.A., White C.J. (2017). Review of climate impact change work undertaken, research gaps and opportunities in the Tasmanian context: Technical report. Antarctic Climate & Ecosystems Cooperative Research Centre, Hobart, Australia

Love, P., Remenyi, T.A., Fox-Hughes, P., Harris, R.M.B., Bindoff, N.L. (2017). Impact of climate change on weather-related fire risk factors in the TWWHA - Part 2. Antarctic Climate & Ecosystems Cooperative Research Centre, Hobart Australia

Sea Ice Services

The ACE CRC also provided sea ice reporting and analytical services to Antarctica-bound vessels during the 2017/18 year, including *RSV Aurora Australis*, *RV l'Astrolabe*, *RV Investigator*, *HMNZS Otago* (New Zealand) and a commercial fishing operator. This service included providing software, data and images (MODIS images and sea ice concentration maps) and associated training/support.

In addition to data provision, weekly Sea Ice Reports (with sub-weekly updates where requested) were provided to AAD Operations, as well as to the New Zealand Defence Force (*HMNZS Otaga*), the Australian Marine National Facility (*RV Investigator*) and a commercial fishing operator.

Wind-Up Plan

Ceasing Operations

The ACE CRC will be wound up following the end of the current funding which covered the period 1 July 2014 to 30 June 2019.

The actual wind up date may fall a little after 30 June 2019, as it will take some time to complete the necessary activities, including reporting and acquittal requirements to the Commonwealth Department.

Governance and Management

The Board is required to ensure that:

- All participants are aware of their roles and responsibilities
- Appropriate management resources are in place to complete all obligations under the Funding Agreement
- Appropriate arrangements are in place to ensure all contractual obligations to staff are met, together with providing HR assistance to staff as needed to find new employment opportunities.
- The appropriate storage and archiving of documentation with relevant parties, particularly contract material, so that it is accessible by the Commonwealth for a period of at least seven years.

[It is understood that CRCs are eligible to have the contents of their websites archived at no cost using the PANDORA web archive project administered by the National Library of Australia and state libraries.]

Final Payments

Most current staff have contracts that cease on 31 May 2019. This date was selected so as to allow coverage for four weeks severance payments at the end of contract period to be included the 2018-19 operational budgetary budgets (note - ACE CRC is responsible for the first four weeks of any applicable severance payment, with any remaining liabilities being the responsibility of UTAS, using the Central Levy Fund Provisions). A small number of staff have contracts ending 30 June 2019; in this case additional provision for applicable severance payments has been specifically provided for in the 2018-19 Wind Up budget.

Annual leave balances at the end of the contract periods will also need to be paid from ACE CRC funds – estimated amounts for these have been included in the wind up budget and are being closely monitored.

Identification of possible employment opportunities

All ACECRC funded staff who cease employment (with UTAS) will be entitled to receive applicable severance payments and payout of annual and long service leave balances. ACE CRC is responsible for payment of all annual leave balances and the first four weeks of any applicable severance payments. UTAS is responsible for any remaining severance costs and all Long Service Leave entitlements.

However, the future for Antarctic science is bright. As more detail becomes available on the scope and staffing required to support the new Antarctic Science Funding measures announced in the 2018/19 budget it is likely that some ACECRC employees will be competitive to secure new roles within these new collaborative arrangements. While there can be no expectations that a transition to the new collaborative entity will occur, for those who are successful it should be a relatively straightforward process to extend and transfer existing (UTAS) employment contracts to a new "unit" if UTAS is the centre administrative agent.

The role of ACECRC is to support staff in preparing them to be competitive for any job opportunities beyond the life of the CRC.

Extension of contracts for staff who will undertake ceasing operations tasks

A matter for consideration by the board is the extension of contracts for a minimal number of staff to oversee and conduct the wind-up activities.

Student Supervision

Students with ACE CRC supervisors will need appropriate transition arrangements. There are currently three ACE CRC cash-funded staff members with primary supervisory responsibilities, with one of these being a permanent UTAS status. Students are required to have a minimum of two supervisors and arrangements will need to be confirmed for continued supervision of any students completing courses. It is expected that IMAS staff will be in a position to manage this.

Student Scholarships

It is proposed that continued funding of residual student scholarship top-up commitments in 2019-20/21 be managed with IMAS, with appropriate transfer of funds (these total just over $8,000) to IMAS prior to wind up.

Data archiving, storage management and access

All ACE CRC Antarctic and Southern Ocean research data is managed by the Australian Antarctic Division as a matter of course, with suitable archiving arrangements already in place. This will ensure data availability for the future.

Climate Futures project research data is currently managed by UTAS TPAC organisation unit, and discussions will need to be held with UTAS in relation to archiving and provision of continued access to this data.

Discussions will also be need to be held with UTAS in relation to archiving all "corporate" data, including contracts, payroll and human resources, email etc. It is thought that this will be a relatively straightforward matter given that UTAS is the legal party to all the contracts. and is the formal employer of all staff and students.

It will be important to ensure that the ACE CRC publication database is fully updated, ready for archiving, and decisions taken in relation to the domain name and website.

The remainder of ACE CRC documentation, in the form of hard copy records, publications, books etc are probably best handed over to the UTAS library, given UTAS has been the Centre Agent since inception.

Contact Details

The CRC is required to include contact details of at least one CRC staff member responsible for managing the ceasing operations process and who can be contacted after the agreement period to assist the department with any outstanding reporting requirements or information requests. As per above it is proposed that the CEO and Business Manager undertake this role.

Activities Status

The ACE CRC activities comprise mainly the "core" Commonwealth grant-funded research program, but there are also some externally funded complementary activities; these being mainly the Climate Futures Research team activity and the Sea-Ice operation service.

All ACE CRC research activities will cease on or before 30 June 2019.

With regard to core program outputs, the following table summarises outputs/deliverables that remain outstanding as at 30 June 2018:

Outputs yet to be completed/milestones yet to be achieved	**Expected status at end of agreement period (completed/terminated/transferred)**	**If transferred, organisation(s) responsible for ongoing activities after the agreement period**
R1.3.3 Change in fast ice distribution and coupling to ocean/ice/ecosystems elements quantified; attribution of change in sea ice distribution completed	Originally due 30 June 2017. Rescheduled and now confident of completion by June 2019	NA

Outputs yet to be completed/milestones yet to be achieved	Expected status at end of agreement period (completed/terminated/transferred)	If transferred, organisation(s) responsible for ongoing activities after the agreement period
R1.4.3 Improved constraints on the physical mechanisms responsible for periods of major change (last deglaciation) developed	Originally due 30 June 2017. Rescheduled and now confident of completion by June 2019	NA
R1.3.4 Marginal Ice Zone (MIZ) experiment to quantify ice-ocean-atmosphere interactions at time of change in sea-ice distribution completed	Originally due 30 June 2018. Refocussed and now confident of completion by June 2019	NA
R1.3.4! First estimate of East Antarctic sea ice volume at maximum extent.	Originally due 30 June 2018. Rescheduled and now confident of completion by June 2019	NA
R2.2.4 Laboratory experiments testing effects of multiple environmental stressors on microbes and krill completed	Originally due 30 June 2018. Rescheduled and now confident of completion before June 2019	NA
R2.3.4 Design of an optimal, circumpolar field observation program to measure ecosystem change at broad scales completed	Originally due 30 June 2018. Rescheduled and now confident of completion by June 2019	NA
R1.1.5 – Integrated assessment of Southern Ocean change, including quantification of the human contribution, delivered.	Not due until 30 June 2019. On track.	NA
R1.2.5 – Present ice sheet mass budget, its evolution and future projected rates of grounded ice discharge quantified, focussed on the East Antarctic.	Not due until 30 June 2019. On track.	NA
R1.3.5 – Sea-ice parameters and processes from satellite instruments and numerical models validated.	Not due until 30 June 2019. On track.	NA
R1.4.5 – Ice-core records synthesised to derive climate variations on local to global scales and links to the Australian climate.	Not due until 30 June 2019. On track.	NA

Outputs yet to be completed/milestones yet to be achieved	Expected status at end of agreement period (completed/terminated/transferred)	If transferred, organisation(s) responsible for ongoing activities after the agreement period
R2.1.5 – Integrated assessment of Southern Ocean chemical change, including human contributions.	Not due until 30 June 2019. On track.	NA
R2.2.5 – Physiological tipping points of microbes and krill, based on laboratory experiments and autecological modelling assessed.	Not due until 30 June 2019. On track.	NA
R2.3.5 – Circumpolar assessment of observed changes and projected future changes in Southern Ocean habitats, key species and ecosystems published.	Not due until 30 June 2019. On track.	NA

Note - the ACE CRC Board has recently undertaken a risk review in relation to achievement of these outstanding milestones.

The above table shows that no incomplete milestones are expected at the end of the ACE CRC term. However, should some residual tasks remain to be complete, and certainly it is expected that some further leverage of research outputs and outcomes will be possible, then this will be a matter for the relevant Participant.

In relation to the Climate Futures team activities, all current contract obligations are due to be completed before 2019, however should some delays occur, or should new contracts be entered into during the 2018-19 financial year that involve delivery beyond 30th June 2019, it is intended that appropriate arrangements will be reflected in the contract arrangements for UTAS (who in any case are the legal party entering into the contracts as the Centre Agent) to be responsible post 30 June 2019.

Financial management and budget provisions

Strong financial management arrangements are in place in the ACE CRC, with all remaining financial commitments identified and included in budgets. With the field program largely complete the main cost driver is employee contracts and these are all being tightly managed. Monthly cash flow statements and forecasts will be monitored closely.

Nonetheless the budget includes some contingency funds of approximately $200K that can be utilised for unforeseen costs or where opportunities arise over the coming months to improve milestone delivery outputs.

No financial commitments beyond 30 June 2019 are expected but should any arise then either they will dealt with as part of the ceasing operations process and be funded either from remaining unspent budgeted funds or from the contingency fund.

Final year budget

The ACE CRC Board has approved the final year budget. This includes provision (accrual) of $113K to cover salary expenses of employees who will manage the ceasing operations process post 30 June 2019. At this stage no CRC grant funds are forecast to remain post wind up. As indicated above, it is possible some residual funds will remain at wind-up and discussions will be held with the Department to determine how to deal with any unexpended funds.

Cash Budget for Final Year of Operation ($000s)

Opening balance	$1,542
Income	
CRC Programme grant	$5,000
Other income	$0,000
Total income	$5,000
Total resources (opening balance + total income)	$6,542
Expenses	
Employee expenses	$4,043
Supplier expenses	$1,410
Other expenses	$0,503
Capital item expenses	$1,723
Total expenses	$6,542
Net balance	$0,113
Accrued expenses	$0,113
Remaining funds	$Nil

Management of intellectual property (IP)

Advice received from UTAS Business Development Manager is that, due to the nature of the ACE CRC intellectual property being creative commons and open source, it is unlikely to be registrable in a way that could allow a commercial partner to secure proprietary rights, and adopting a conventional "IP audit" forma (recoding inventory, priority dates, evidence for reduction to practice) is unlikely to be an efficient way to proceed. Rather it was suggested that the primary focus should be on data archiving, storage, maintenance and access. The wind-up approach in relation to data management is discussed above.

Assets

The ACE CRC does not own any assets. Major capital equipment purchases using the Commonwealth Grant funds were transferred to the relevant partner (in most cases Argo floats to CSIRO) as part of the partnership agreement arrangements.

The ACE CRC motor vehicle and minor assets (e.g. computers, laboratory equipment) are owned by UTAS with an amortisation charge to the ACE CRC. Upon wind up, all of these assets will remain UTAS property.

Taxation

There should be no tax liabilities beyond the normal payroll and GST matters handled by the CRC Centre Agent (UTAS).

Post June 2019 Wind up Activities

The main post 30 June 2019 wind up activities are:

- Final Annual Report, including Exit Report and final financial statements
- Final CRC Online reporting including financial reports, tables, management data questionnaire and online milestone reporting
- Ensuring any residual invoices are paid (having sought to have as many as possible paid prior to 30 June 2019)
- Transfer of any residual funds in the UTAS CRC accounts to the board approved entity/ies
- Arranging the handling of any outstanding liabilities (e.g. remaining scholarship obligations)
- Finalise and implement data archiving and management arrangements
- Website modified to advise of CRC closure, contact details etc
- Director resignation notices
- Appropriate physical transfer of equipment, furniture and photos/artworks etc to UTAS
- Closure of office including cancellation of passes, email etc, and any associated support services (printer maintenance, newspaper supplies, subscriptions)

Exit Report

Summary of the ACE CRC

Overview

The ACE CRC has been a strong, long-standing and productive collaboration between seven core partners and fourteen supporting partners. The core partners are the Australian Antarctic Division, CSIRO, the University of Tasmania, the Bureau of Meteorology, the Commonwealth Government's Department of the Environment and Energy (under numerous formal names over the life time of the Centre), plus the Alfred Wegener Institute for Polar and Marine Research (Germany) and the National Institute of Water and Atmospheric Research (New Zealand).

Originally established in 1991, the ACE CRC was successful in five selection rounds:

- 1991 CRC for the Antarctic and Southern Ocean Environment;
- 1996 CRC for Antarctica and the Southern Ocean;
- 2002 CRC for Antarctic Climate and Ecosystems;
- 2009 CRC for Antarctic Climate and Ecosystems; and
- 2014 CRC for Antarctic Climate and Ecosystems

The ACE CRC's latest incarnation was funded through the Australian Government's Cooperative Research Centres Program under a Commonwealth Agreement covering the period from 1 July 2014 to 30 June 2019. The supporting partners include research and academic institutions based in Australia and abroad, as well as one commercial consulting business.

Following the introduction of new CRC program funding guidelines in 2015 the ACE CRC was no longer eligible to apply for any further extensions and will be wound up following completion of its current funding term.

Over its life, the ACE CRC was able to attract over $700 million in Australian and international funds in in-kind support. During this five-year funding term alone, it attracted over $120 million in in-kind support.

This collaboration and in-kind support has been vital in enabling the ACE CRC to act as the primary mechanism by which Australia's Antarctic research sector can assemble multi-disciplinary teams of experts to address strategic science questions, particularly those relating to Climate Change, which cannot be tackled by one institution alone. These collaborations have enabled the ACE CRC and its partners to define the agenda for Southern Ocean and Antarctic research globally and helped in establishing Tasmania as a global centre for Antarctic innovation.

Major Achievements

The ACE CRC has delivered significant impact by providing relevant, timely and actionable scientific advice to policy makers, industry stakeholders and the broader public. During the life of the ACE CRC, the Centre continuously sought new and innovative ways to communicate its research outcomes to maximise the uptake of its scientific work. The ACE CRC established a reputation for providing the clear and actionable scientific insights necessary to ensure Australia can successfully meet the challenges of a changing climate.

The Centre's plain-English *Position Analysis* and *Report Card* publications summarised the latest developments in sea level rise, climate change, ocean acidification, sea ice distribution, ocean fertilisation and ocean ecology. To ensure uptake at the policy level, the Centre proactively engaged with relevant departmental offices and parliamentary offices on a regular basis. The Centre's scientists issued regular public statements and made numerous appearances in the media to provide an informed perspective on often-contentious issues relating to climate change. The Centre also conducted regular reviews with end-users to understand their needs and continually improve outputs, and also held bi-annual symposiums attended by a wide range of end-users, stakeholders and the broader community.

Research

The ACE CRC's science has been world leading. As a key driver of research and innovation, the ACE CRC has nurtured the scientific expertise, institutional links and industry innovation that has helped establish Australia's reputation for leadership and stewardship in the Antarctic.

During the current funding period, ACE CRC researchers have published over 480 peer-reviewed scientific papers, including 35 in the prestigious family of *Nature* and *Science* journals. This body of knowledge constitutes a major contribution to global scientific understanding of climate change and its local, regional and global impacts.

The ACE CRC's scientists have led Australian contributions to major deliberations by international governance bodies including the Intergovernmental Panel on Climate Change (IPCC), the Commission for the Conservation of Marine Living Resources (CCAMLR) and the International Maritime Organisation (IMO).

Through a long running ocean-sampling program, the ACE CRC has enabled the development of a vastly improved understanding of the Southern Ocean's fundamental role in regulating and driving ocean circulation.

Our research has also shown that the Southern Ocean is acting as a powerful handbrake on the rate of global climate change, but at the cost of increasing warming and acidification.

Furthermore, we found that the great Antarctic ice sheet, holding around 70 percent of the planet's fresh water, is melting at an accelerating rate under the effects of the changing ocean and atmosphere.

Our ecologists have shed new light on the impacts of these changes on fundamental ecological processes including krill reproduction and phytoplankton distribution, with major implications for fisheries and marine park management.

And of major significant nationally, are findings that demonstrate the intimate connection between our continent's weather systems, including droughts and floods, emerge largely from powerful atmospheric processes over the Southern Ocean and Antarctica.

Commercialisation and utilisation

The ACE CRC has been a public-good research centre focussed on the important role of Antarctica and the Southern Ocean in the global climate system, and on climate change and its impacts in the Antarctic, Australia and the world.

The value of the ACE CRC's intellectual property can be measured by its social and environmental impact. As a public good CRC, and also consistent with the approach implicit in the Antarctic Treaty, the ACE CRC made its research outputs widely and freely available.

The nature of ACE CRC research being created and utilised via creative commons and open sourcing, and in general the approach to full sharing of research within the Antarctic research community has delivered substantial economic benefits but has precluded the building of commercial outcomes.

The ACE CRC has undertaken a wide variety of activities to communicate our research outcomes to maximise awareness and uptake of our scientific work. Outreach activities have taken place with elected representatives, policy makers and the public, as well as within the science community. During this funding term, bi-annual ACE CRC Symposiums (approximately 150-200 attendees) and regular End-user Research Forums (held twice yearly and with approximately 60 attendees) have been key means to communicate research findings to end-users, key stakeholders and the broader community. These events also promoted a sense of community and common purpose among researchers associated with the ACE CRC, strengthened staff and student commitment to the ACE CRC and fostered collaboration among participants. The symposia have been attended by ACE CRC end users from government and industry, and have been an outstanding success.

During the funding period, the ACE CRC held two Symposia (August 2016 and August 2018) and three research user forums in Canberra where the following Position Analysis were presented:

- The Antarctic Ice Sheet and Sea Level

- Managing Southern Ocean Ecosystems
- Ice Cores and Climate
- Ocean Fertilisation
- The Antarctic Sea Ice and Climate Change

SME Engagement

Earlier funding terms of the CRC have included small business enterprises within the partnership structure, and this continued in the 2014-19 term, with SGS remaining as an 'Other' Participant within the partnership structure. The ACE CRC and SGS undertook a number of collaborative projects during this period, mainly involving assessments of climate change implications for end-user organisations.

Education and training

The ACE CRC's education program has been provided through the Institute for Marine and Antarctic Studies (IMAS), which is part of the University of Tasmania. Students studying at IMAS are part of an exciting, world class program focusing on some of the most important scientific questions of our age which include a range of topics relevant to Antarctica and the Southern Ocean.

The relationship between the research programs and students has been symbiotic. While the students gained much from their exposure to theoretical and practical science – including fieldwork in the Antarctic and Southern Ocean – so too has the CRC's research gained much from the students' contributions.

Throughout its life, the ACE CRC gave high priority to training, each year providing postgraduate opportunities for 50 or more students in a wide array of disciplines. While centred on Antarctica, the education of students addressed the needs of specific disciplines such as oceanography, glaciology and atmospheric science. Aside from postgraduate teaching, ACE CRC staff also taught Masters and Honours students and units in undergraduate courses, mostly to students taking science degrees, although a few undergraduates from other backgrounds (e.g., Arts) did enrol in first-year Antarctic studies units.

A total of 37 PhD students graduated in the 2014-19 term with the ACE CRC supporting close to 300 PhD students over its lifetime, many of whom have gone on to prominent appointments locally and around the world.

International engagement

The ACE CRC engaged on the international stage in a number of different ways. Firstly, we had 21 institutional partners with whom we collaborated on significant scientific research projects. Antarctic and Southern Ocean research is complex and expensive, and takes many years to plan and undertake, so there is great benefit in collaborating across organisations, disciplines and national boundaries. ACE provided a unique mechanism to collaborate with international partners, giving Australian researchers an opportunity to engage internationally, and leveraging Australian Government investment in research many times over. A good example of this included the ICECAP project, where ACE CRC scientists leveraged the resources and infrastructure of the US and Australian Antarctic programs to survey large areas of East Antarctica.

ACE CRC scientists also engaged directly, and at very senior levels, with major international research programs and coordinating bodies, such as the Scientific Committee on Antarctic Research (SCAR), Intergovernmental Panel on Climate Change (IPCC), Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR), and the International Whaling Commission (IWC).

Case Study - Intergovernmental Panel on Climate Change

The Intergovernmental Panel on Climate Change (IPCC) is the international body responsible for providing governments with the largest and most comprehensive summary of the latest scientific information on climate change. The contributions of ACE CRC staff over several years to the release of the IPCC's Fifth Assessment Report (AR5) in 2013 represented a major commitment to end-users nationally and globally.

The ACE CRC is again playing a leading role in preparing the IPCC Sixth Assessment Report (AR6), with six ACE CRC researchers being among those selected to contribute as either lead authors, contributing authors, reviewers or editors. The report constitutes the most comprehensive and definitive body of scientific evidence demonstrating anthropogenic factors driving climate change.

Economic Benefits

As a public good CRC engaged in the fundamental science of climate change, the economic impacts of the Centre's research should be measured against the impact of mitigating likely future productivity losses resulting from climate change. This is not an easy task.

In the past broad assessments have been undertaken by the ACE CRC but in in this past year another approach involving a more targeted assessment of the impact of a particular output from the CRC was adopted. In October 2017, the ACE CRC contracted Agtrans Research to conduct an Impact Assessment of investment in the Climate Futures Tasmania ("CFT") Initiative. The impact assessment was funded to demonstrate the impact of a significant RD&E investment by the ACE CRC and partners.

The investment in the CFT Initiative for the period 2008-2017, based on the best bet assumptions made and sensitivity analyses of key variables, has been estimated to produce a present value of benefits of between $21.5 million and $86.5 million (present value terms) from total investment costs of approximately $16.4 million (present value terms). This produced a net present value of between $5.1 million and $70.0 million and a benefit-cost ratio of between 1.3 and 5.3 to 1. The best estimate of a net present value of $26.6 million, and a benefit-cost ratio of approximately 2.6 to 1, was considered to be an outstanding result and is within the range of benefit-cost ratios for other CRCs and other climate RD&E programs that have been estimated over the past ten years by Agtrans Research.

Case Study - Climate Futures for Tasmania

In 2010 the Tasmanian Government launched Climate Futures for Tasmania, a project developed by the ACE CRC to model projected changes to Tasmania's climate during this century, and its impact on communities, industries and government agencies. The project provided the first fine-scale climate information for Tasmania by downscaling six global climate models with two emission scenarios to generate climate information from 1961 to 2100. The project interprets climate

projections at a local scale, so that communities, industries and individuals can use information in their local planning and adaptation actions.

The project also looked at the impacts in the applied areas of water and catchments, assessing how water will flow through various Tasmanian water catchments and into storage reservoirs under different climate scenarios. The project also provided specific climate indicators relevant to productivity in key areas of Tasmanian agricultural production. Finally, working with emergency service agencies, the project identified the climate variables of greatest concern to emergency managers.

Following the release of the report, many flow on research projects have been, and are continuing to be, undertaken to significantly leverage this core research. These projects undertaken by the ACE CRC's Climate Futures Unit over the current CRC term, and funded by end-users, have included future rainfall patterns for Hydro Tasmania's infrastructure planning purposes, several future fire and flood predictions used by State Emergency Services to improve natural disaster preparedness planning and mitigation, and various agricultural sector analyses to guide decisions on future investment in the context of future climate change risk and opportunities

The Tasmanian Government describes the project as its "most important source of climate change projections at a local scale… [and] an essential part of Tasmania's climate change strategy." The project was made possible through the support of a consortium of government and private sector partners.

Collaboration

Overview

Collaboration has been the driving force behind all of the ACE CRC's scientific projects, and the key to its success as a research organisation.

Unincorporated Joint Venture Partners

The Centre was an unincorporated joint venture comprising 7 essential and 14 other participants. The seven Essential Participants were bound by the Participants Agreement, and the Other Participants Agreements set out the duties and commitments of the remaining parties.

Type of Participant	Participant
Essential	Alfred Wegener Institute of Polar and Marine Research (AWI), Germany
Essential	Australian Antarctic Division (AAD)
Essential	Australian Bureau of Meteorology (BOM)
Essential	CSIRO Division of Oceans and Atmosphere (CSIRO)
Essential	Department of the Environment and Energy
Essential	National Institute of Water and Atmospheric Research Ltd (NIWA), New Zealand
Essential	University of Tasmania (UTAS)

Type of Participant	Participant
Other	Centre for Polar Oceanography and Modelling (CPOM), University College London, UK
Other	Chinese Academy of Meteorological Science (CAMS)
Other	Curtin University
Other	First Institute of Oceanography (FIO), China
Other	Institute of Low Temperature Science (ILTS), Hokkaido University, Japan
Other	Laboratoire d'Etudes en Géophysique et Océanographie Spatiales (LEGOS), France
Other	National Institute of Polar Research (NIPR), Japan
Other	Old Dominion University (ODU), USA
Other	SGS Economics and Planning Pty Ltd
Other	Tasmanian Government
Other	Tokyo University of Marine Science and Technology
Other	University of Texas at Austin, USA
Other	University of Texas at San Antonio, USA
Other	Vrije Universiteit Brussel (VUB), Belgium

Research Project Partnerships

The ACE CRC operated on the principle that much more can be achieved through collaboration than by working alone. Antarctica is an extreme environment, and the climate systems we study there are indifferent to national and institutional boundaries. To produce high quality science demands a high level of co-operation. At a project level, the ACE CRC maintained over 110 domestic and international collaborations. One example of a collaborative project both domestically and internationally is the ICECAP project which is further detailed below.

Case Study – Collaboration – ICECAP (International Collaboration for Exploration of the Cryosphere through Aerogeophysical Profiling)

The ACE CRC's participation in the international ICECAP project has enabled a major detailed airborne geophysical survey covering large areas of East Antarctica, filling in a vast blank on the map of Australia's Antarctic territory. Using airborne laser and ice penetrating radar instruments, magnetometers and gravimeters, huge areas of the East Antarctic have been surveyed in high resolution for the first time. The data will enable ACE CRC scientists to understand how ice flows from the continent into the ocean and, ultimately, how much this process might contribute to sea level rise.

The ICECAP collaboration involves the ACE CRC and partner institutions: the Australian Antarctic Division; the University of Texas at Austin; the Laboratoire d'Etudes en Géophysique et Océanographie Spatiales (LEGOS); and non-partner Universities of Edinburgh, Bristol and Exeter. The project has been a highly successful mechanism for international collaboration, leveraging 'in-kind' contributions from national and international partners and funding from peak agencies such as NASA and UK's NERC, in excess of five times the ACE CRC's cash investment. The benefits of the partnership include access to scientific expertise, sharing of highly specialised sensing technology and logistics, and integration of Australian scientists into a world-class research team.

The data collected from hundreds of thousands of kilometres of flight-lines has enormously enhanced our understanding of the East Antarctic ice sheet, including revealing that much more of it rests on bedrock well below sea level than previously thought and therefore may be more vulnerable to a warming ocean and contribute more to future sea level rise than previously thought. The measurements of magnetic properties of the hidden bedrock have also provided recently published insights connecting the geology of East Antarctica and Australia associated with the break-up of past supercontinents.

As a component of NASA's Operation IceBridge, ICECAP flights along tracks previously surveyed by ICESat have extended and improved the precision mapping of the ice sheet elevation, demonstrating the power of advanced scanning laser systems, and gaining valuable insights into the current changes in East Antarctica.

Publications

Since 2014 ACE CRC researchers have published well over 480 peer-reviewed scientific papers, including 35 in Nature and Science journals.

It should also be noted that over the 28-year life of the CRC, ACE CRC researchers have published well over 2,000 peer-reviewed scientific papers. These peer-reviewed scientific papers have had over 60,000 citations with 85 scientific papers published in high profile journals such as *Nature* and *Science*.

Value for Participants

The ACE CRC has been a highly cost-effective mechanism for driving collaboration, leveraging 'in kind' contributions from our national and international partners in excess of five times the cash investment. The ACE CRC has been the primary mechanism by which teams of experts are assembled from across our partners to address strategic, multi-disciplinary science questions that cannot be tackled by one institution alone.

Impact of education programs on industry, the sector in general and on skills development

Key educational outputs

From 1 July 2014 to June 2018, 37 students were awarded PhD degrees with 67 continuing PhD students.

More than 500 students have completed their honours and research higher degrees (PhD and Masters) with the CRC since its establishment in September 1991. The centre has produced students with skills applicable to a wide variety of

environmental and policy fields such as oceanography, meteorology, biology, international law, etc.

The impact of education and training programs in areas of skill shortages

The ACE CRC has been an impressive incubator of Australian science innovation, with approximately 185 PhD completions during its lifetime. One of the objectives of the ACE CRC's education program during the reporting period was to address the long-term unmet national demand for highly-trained personnel with quantitative skills in oceanography and marine ecology. Significant progress was made towards this objective during the life of the Centre, with many graduates progressing to high-profile professional careers with partner institutions, governments and industry world-wide.

Through partnership with IMAS, the ACE CRC has contributed to the production of the highly popular online course Marine and Antarctic Science. This free online course consists of 37 short videos across four modules, each with a range of quizzes and assessment tasks. Subject material includes how life evolved in the sea, the role of the ocean in climate and the impacts of climate change for ocean processes and marine biota.

Appendix 1– list of publications

Book Chapters

Rintoul, S., Feng, M., Hardman-Mountford, N. and Raes, E. (2017). Australia's ocean currents. Oceans: Science and Solutions for Australia. Mapstone, B. Clayton, Australia, CSIRO Publishing**:** 13-24.

Articles in Scholarly Refereed Journals

Alexander, S.P., Orr, A., Webster, S. and Murphy, D.J. (2017). "Observations and fine-scale model simulations of gravity waves over Davis, East Antarctica (69°S, 78°E)." Journal of Geophysical Research: Atmospheres **122**(14): 7355-7370.

Alexander, S.P. and Protat, A. (2018). "Cloud Properties Observed From the Surface and by Satellite at the Northern Edge of the Southern Ocean." Journal of Geophysical Research: Atmospheres **123**(1): 443-456.

Aoki, S., Kobayashi, R., Rintoul, S.R., Tamura, T. and Kusahara, K. (2017). "Changes in water properties and flow regime on the continental shelf off the Adélie/George V Land coast, East Antarctica, after glacier tongue calving." Journal of Geophysical Research: Oceans **122**(8): 6277-6294.

Armbrecht, L.H., Eriksen, R., Leventer, A. and Armand, L.K. (2017). "First observations of living sea-ice diatom agglomeration to tintinnid loricae in East Antarctica." Journal of Plankton Research **39**(5): 795-802.

Baringer, M.O., Smeed, D.A., Willis, J., Lankhorst, M., Hobbs, W.R., Dong, S., McCarthy, G., Rayner, D., Johns, W.E., Goni, G. and Send, U. (2017). "Meridional overturning and oceanic heat transport circulation observations in the North Atlantic Ocean [in State of the Climate in 2016]." Bulletin of the American Meteorological Society **98**(8): S84-S87.

Benn, D.I., Åstrom, J.A.N., Zwinger, T., Todd, J.O.E., Nick, F.M., Cook, S., Hulton, N.R.J. and Luckman, A. (2017). "Melt-under-cutting and buoyancy-driven calving from tidewater glaciers: new insights from discrete element and continuum model simulations." Journal of Glaciology **63**(240): 691-702.

Bestley, S., Raymond, B., Gales, N.J., Harcourt, R.G., Hindell, M.A., Jonsen, I.D., Nicol, S., Péron, C., Sumner, M.D., Weimerskirch, H., Wotherspoon, S.J. and Cox, M.J. (2017). "Predicting krill swarm characteristics important for marine predators foraging off East Antarctica." Ecography: n/a-n/a.

Boyd, P.W., Collins, S., Dupont, S., Fabricius, K., Gattuso, J.P., Havenhand, J., Hutchins, D.A., Riebesell, U., Rintoul, M.S., Vichi, M., Biswas, H., Ciotti, A., Gao, K., Gehlen, M., Hurd, C.L., Kurihara, H., McGraw, C.M., Navarro, J.M., Nilsson, G.E., Passow, U. and Pörtner, H.O. (2018). "Experimental strategies to assess the biological ramifications of multiple drivers of global ocean change-A review." Global Change Biology **24**: 2239-2261.

Buchanan, P.J., Matear, R.J., Chase, Z., Phipps, S.J. and Bindoff, N.L. (2018). "Dynamic Biological Functioning Important for Simulating and Stabilizing Ocean Biogeochemistry." Global Biogeochemical Cycles **32**(4): 565-593.

Bühl, J., Alexander, S., Crewell, S., Heymsfield, A., Kalesse, H., Khain, A., Maahn, M., Van Tricht, K. and Wendisch, M. (2017). "Remote Sensing - Ice Formation and Evolution in Clouds and Precipitation: Measurement and Modeling Challenges." Meteorological Monographs **58**: 10.11-10.21.

Cavanagh, R.D., Murphy, E.J., Bracegirdle, T.J., Turner, J., Knowland, C.A., Corney, S.P., Smith, W.O., Waluda, C.M., Johnston, N.M., Bellerby, R.G.J., Constable, A.J., Costa, D.P., Hofmann, E.E., Jackson, J.A., Staniland, I.J., Wolf-Gladrow, D. and Xavier, J.C. (2017). "A Synergistic Approach for Evaluating Climate Model Output for Ecological Applications." Frontiers in Marine Science **4**(308).

Cavitte, M.G.P., Parrenin, F., Ritz, C., Young, A., Van Liefferinge, B., Blankenship, D.D., Frezzotti, M. and Roberts, J.L. (2018). "Accumulation patterns around Dome C, East Antarctica, in the last 73 kyr." Cryosphere **12**(4): 1401-1414.

Cimoli, E., Meiners, K.M., Lund-Hansen, L.C. and Lucieer, V. (2017). "Spatial variability in sea-ice algal biomass: an under-ice remote sensing perspective." Adv Polar Sci **28** (4): 268-296.
Constable, A.J. and Kawaguchi, S. (2018). "Modelling growth and reproduction of Antarctic krill, Euphausia superba, based on temperature, food and resource allocation amongst life history functions." ICES Journal of Marine Science **75**(2): 738-750.
Cougnon, E.A., Galton-Fenzi, B.K., Rintoul, S.R., Legrésy, B., Williams, G.D., Fraser, A.D. and Hunter, J.R. (2017). "Regional Changes in Icescape Impact Shelf Circulation and Basal Melting." Geophysical Research Letters **44**(22): 11519-11527.
Czechowski, P., Clarke, L., Cooper, A. and Stevens, M. (2017). Ground-truthing Phylotype Assignments for Antarctic Invertebrates. DNA Barcodes. **5:** 1.
Deagle, B.E., Clarke, L.J., Kitchener, J.A., Polanowski, A.M. and Davidson, A.T. (2018). "Genetic monitoring of open ocean biodiversity: An evaluation of DNA metabarcoding for processing continuous plankton recorder samples." Molecular Ecology Resources **18**(3): 391-406.
Deagle, B.E., Thomas, A.C., McInnes, J.C., Clarke, L.J., Vesterinen, E.J., Clare, E.L., Kartzinel, T.R. and Eveson, J.P. "Counting with DNA in metabarcoding studies: How should we convert sequence reads to dietary data?" Molecular Ecology **0**(0).
Della Penna, A., Trull, T.W., Wotherspoon, S., De Monte, S., Johnson, C.R. and d'Ovidio, F. (2018). "Mesoscale Variability of Conditions Favoring an Iron-Induced Diatom Bloom Downstream of the Kerguelen Plateau." Journal of Geophysical Research: Oceans **123**(5): 3355-3367.
Deppeler, S., Petrou, K., Schulz, K.G., Westwood, K., Pearce, I., McKinlay, J. and Davidson, A. (2018). "Ocean acidification of a coastal Antarctic marine microbial community reveals a critical threshold for CO2 tolerance in phytoplankton productivity." Biogeosciences **15**(1): 209-231.
Deppeler, S.L. and Davidson, A.T. (2017). "Southern Ocean phytoplankton in a changing climate." Frontiers in Marine Science **4**(FEB).
Downes, S.M., Langlais, C., Brook, J.P. and Spence, P. (2017). "Regional impacts of the westerly winds on Southern Ocean mode and intermediate water subduction." Journal of Physical Oceanography **47**(10): 2521-2530.
Downes, S.M., Spence, P. and Hogg, A.M. (2018). "Understanding variability of the Southern Ocean overturning circulation in CORE-II models." Ocean Modelling **123**: 98-109.
Durand, A., Chase, Z., Noble, T.L., Bostock, H., Jaccard, S.L., Townsend, A.T., Bindoff, N.L., Neil, H. and Jacobsen, G. (2018). "Reduced oxygenation at intermediate depths of the southwest Pacific during the last glacial maximum." Earth and Planetary Science Letters **491**: 48-57.
Ellwood, M.J., Bowie, A.R., Baker, A., Gault-Ringold, M., Hassler, C., Law, C.S., Maher, W.A., Marriner, A., Nodder, S., Sander, S., Stevens, C., Townsend, A., van der Merwe, P., Woodward, E.M.S., Wuttig, K. and Boyd, P.W. (2018). "Insights Into the Biogeochemical Cycling of Iron, Nitrate, and Phosphate Across a 5,300 km South Pacific Zonal Section (153°E–150°W)." Global Biogeochemical Cycles **32**(2): 187-207.
Emile-Geay, J., McKay, N., Kaufman, D., von Gunten, L., Wang, J., Anchukaitis, K., Abram, N., Addison, J., Curran, M., Evans, M., Henley, B., Hao, Z., Martrat, B., McGregor, H., Neukom, R., Pederson, G., Stenni, B., Thirumalai, K., Werner, J., Xu, C., Divine, D., Dixon, B., Gergis, J., Mundo, I., Nakatsuka, T., Phipps, S., Routson, C., Steig, E., Tierney, J., Tyler, J., Allen, K., Bertler, N., Björklund, J., Chase, B., Chen, M.-T., Cook, E., de Jong, R., DeLong, K., Dixon, D., Ekaykin, A., Ersek, V., Filipsson, H., Francus, P., Freund, M., Frezzotti, M., Gaire, N., Gajewski, K., Ge, Q., Goosse, H., Gornostaeva, A., Grosjean, M., Horiuchi, K., Hormes, A., Husum, K., Isaksson, E., Kandasamy, S., Kawamura, K., Kilbourne, K., Koç, N., Leduc, G., Linderholm, H., Lorrey, A., Mikhalenko, V., Mortyn, P., Motoyama, H., Moy, A., Mulvaney, R., Munz, P., Nash, D., Oerter, H., Opel, T., Orsi, A., Ovchinnikov, D., Porter, T., Roop, H., Saenger, C., Sano, M., Sauchyn, D., Saunders, K., Thomas, M.-S., Severi, M., Shao, X., Sicre, M.-A., Sigl, M., Sinclair, K., St. George, S., St. Jacques, J.-M., Thamban, M., Kuwar Thapa, U., Thomas, E., Turney, C., Uemura, R., Viau, A., Vladimirova, D., Wahl, E., White, J., Yu, Z. and Zinke, J. (2017). "A global

multiproxy database for temperature reconstructions of the Common Era." **4**: 170088.
Eriksen, R., Trull, T.W., Davies, D., Jansen, P., Davidson, A.T., Westwood, K. and Van Den Enden, R. (2018). "Seasonal succession of phytoplankton community structure from autonomous sampling at the Australian Southern Ocean Time Series (SOTS) observatory." Marine Ecology Progress Series **589**: 13-21.
Furue, R., Guerreiro, K., Phillips, H.E., McCreary, J.P., Jr. and Bindoff, N.L. (2018). "Corrigendum: On the Leeuwin Current System and its linkage to zonal flows in the south Indian Ocean as inferred from a gridded hydrography [Journal of Physical Oceanography, 47 (2017) (583-602)] DOI:10.1175/JPO-D-16-0170.1." Journal of Physical Oceanography **48**(5): 1231-1232.
Gao, L., Rintoul, S.R. and Yu, W. (2018). "Recent wind-driven change in Subantarctic Mode Water and its impact on ocean heat storage." Nature Climate Change **8**(1): 58-63.
Genovese, C., Grotti, M., Pittaluga, J., Ardini, F., Janssens, J., Wuttig, K., Moreau, S. and Lannuzel, D. (2018). "Influence of organic complexation on dissolved iron distribution in East Antarctic pack ice." Marine Chemistry **203**: 28-37.
Goedegebuure, M., Melbourne-Thomas, J., Corney, S.P., McMahon, C.R. and Hindell, M.A. (2018). "Modelling southern elephant seals mirounga leonina using an individual-based model coupled with a dynamic energy budget." PLoS ONE **13**(3).
Golynsky, A.V., Ferraccioli, F., Hong, J.K., Golynsky, D.A., Frese, R.R.B., Young, D.A., Blankenship, D.D., Holt, J.W., Ivanov, S.V., Kiselev, A.V., Masolov, V.N., Eagles, G., Gohl, K., Jokat, W., Damaske, D., Finn, C., Aitken, A., Bell, R.E., Armadillo, E., Jordan, T.A., Greenbaum, J.S., Bozzo, E., Caneva, G., Forsberg, R., Ghidella, M., Galindo-Zaldivar, J., Bohoyo, F., Martos, Y.M., Nogi, Y., Quartini, E., Kim, H.R. and Roberts, J.L. (2018). "New Magnetic Anomaly Map of the Antarctic." Geophysical Research Letters **45**(13): 6437-6449.
Goodwin, I.D., Roberts, J.L., Etheridge, D.M., Hellstrom, J., Moy, A.D., Ribo, M. and Smith, A.M. (2018). Modern to Glacial age subglacial meltwater drainage at Law Dome, coastal East Antarctica from topography, sediments and jökulhlaup observations. Geological Society Special Publication. **461:** 215-230.
Greene, C.A., Blankenship, D.D., Gwyther, D.E., Silvano, A. and Van Wijk, E. (2017). "Wind causes Totten Ice Shelf melt and acceleration." Science Advances **3**(11).
Greenslade, J.W., Alexander, S.P., Schofield, R., Fisher, J.A. and Klekociuk, A.K. (2017). "Stratospheric ozone intrusion events and their impacts on tropospheric ozone in the Southern Hemisphere." Atmospheric Chemistry and Physics **17**(17): 10269-10290.
Hancock, A.M., Davidson, A.T., McKinlay, J., McMinn, A., Schulz, K.G. and Van Den Enden, R.L. (2018). "Ocean acidification changes the structure of an Antarctic coastal protistan community." Biogeosciences **15**(8): 2393-2410.
Hessl, A., Allen, K.J., Vance, T., Abram, N.J. and Saunders, K.M. (2017). "Reconstructions of the southern annular mode (SAM) during the last millennium." Progress in Physical Geography: Earth and Environment **41**(6): 834-849.
Holmes, T.M., Chase, Z., Van Der Merwe, P., Townsend, A.T. and Bowie, A.R. (2017). "Detection, dispersal and biogeochemical contribution of hydrothermal iron in the ocean." Marine and Freshwater Research **68**(12): 2184-2204.
Janssens, J., Meiners, K.M., Townsend, A.T. and Lannuzel, D. (2018). "Organic matter controls of iron incorporation in growing sea ice." Frontiers in Earth Science **6**.
Johnson, G.C., Lyman, J.M., Boyer, T., Domingues, C.M., Gilson, M., Ishii, M., Killik, R., Monselesan, D. and Wijffels, S.E. (2017). "[Global Oceans] Ocean Heat Content [in 'State of the Climate in 2016]." Bulletin of American Meteorological Society **98**(8): S66-S69.
Kawaguchi, S. and Watanabe, K. (2016). "Report of the 3rd joint Australia-Japan Workshop "Australia and Japan collaboration in Antarctic Science"." Antarctic Record **60**(1): 19-34.
Keller, D.P., Lenton, A., Scott, V., Vaughan, N.E., Bauer, N., Ji, D., Jones, C.D., Kravitz, B., Muri, H. and Zickfeld, K. (2018). "The Carbon Dioxide Removal Model Intercomparison Project (CDRMIP): Rationale and experimental protocol for CMIP6." Geoscientific Model Development **11**(3): 1133-1160.

Kusahara, K., Williams, G.D., Massom, R., Reid, P. and Hasumi, H. (2017). "Roles of wind stress and thermodynamic forcing in recent trends in Antarctic sea ice and Southern Ocean SST: An ocean-sea ice model study." Global and Planetary Change **158**: 103-118.

Kusahara, K., Williams, G.D., Tamura, T., Massom, R. and Hasumi, H. (2017). "Dense shelf water spreading from Antarctic coastal polynyas to the deep Southern Ocean: A regional circumpolar model study." Journal of Geophysical Research: Oceans **122**(8): 6238-6253.

Labrousse, S., Williams, G., Tamura, T., Bestley, S., Sallée, J.B., Fraser, A.D., Sumner, M., Roquet, F., Heerah, K., Picard, B., Guinet, C., Harcourt, R., McMahon, C., Hindell, M.A. and Charrassin, J.B. (2018). "Coastal polynyas: Winter oases for subadult southern elephant seals in East Antarctica." Scientific Reports **8**(1).

Lam, H.M., Spreen, G., Heygster, G., Melsheimer, C. and Young, N.W. (2018). "Erroneous sea-ice concentration retrieval in the East Antarctic." Annals of Glaciology **59**(76pt2): 201-212.

Langlais, C.E., Lenton, A., Matear, R., Monselesan, D., Legresy, B., Cougnon, E. and Rintoul, S. (2017). "Stationary Rossby waves dominate subduction of anthropogenic carbon in the Southern Ocean." Scientific Reports **7**(1).

Le Quéré, C., Andrew, R.M., Friedlingstein, P., Sitch, S., Pongratz, J., Manning, A.C., Ivar Korsbakken, J., Peters, G.P., Canadell, J.G., Jackson, R.B., Boden, T.A., Tans, P.P., Andrews, O.D., Arora, V.K., Bakker, D.C.E., Barbero, L., Becker, M., Betts, R.A., Bopp, L., Chevallier, F., Chini, L.P., Ciais, P., Cosca, C.E., Cross, J., Currie, K., Gasser, T., Harris, I., Hauck, J., Haverd, V., Houghton, R.A., Hunt, C.W., Hurtt, G., Ilyina, T., Jain, A.K., Kato, E., Kautz, M., Keeling, R.F., Klein Goldewijk, K., Körtzinger, A., Landschützer, P., Lefèvre, N., Lenton, A., Lienert, S., Lima, I., Lombardozzi, D., Metzl, N., Millero, F., Monteiro, P.M.S., Munro, D.R., Nabel, J.E.M.S., Nakaoka, S.I., Nojiri, Y., Antonio Padin, X., Peregon, A., Pfeil, B., Pierrot, D., Poulter, B., Rehder, G., Reimer, J., Rödenbeck, C., Schwinger, J., Séférian, R., Skjelvan, I., Stocker, B.D., Tian, H., Tilbrook, B., Tubiello, F.N., Laan-Luijkx, I.T.V., Werf, G.R.V., Van Heuven, S., Viovy, N., Vuichard, N., Walker, A.P., Watson, A.J., Wiltshire, A.J., Zaehle, S. and Zhu, D. (2018). "Global Carbon Budget 2017." Earth System Science Data **10**(1): 405-448.

Lenton, A. (2018). "Constraining ocean transport." Nature Geoscience: 1-2.

Llort, J., Langlais, C., Matear, R., Moreau, S., Lenton, A. and Strutton, P.G. (2018). "Evaluating Southern Ocean Carbon Eddy-Pump From Biogeochemical-Argo Floats." Journal of Geophysical Research: Oceans **123**(2): 971-984.

Malpress, V., Bestley, S., Corney, S., Welsford, D., Labrousse, S., Sumner, M. and Hindell, M. (2017). "Bio-physical characterisation of polynyas as a key foraging habitat for juvenile male southern elephant seals (Mirounga leonina) in Prydz Bay, East Antarctica." PLOS ONE **12**(9): e0184536.

Massom, R.A., Scambos, T.A., Bennetts, L.G., Reid, P., Squire, V.A. and Stammerjohn, S.E. (2018). "Antarctic ice shelf disintegration triggered by sea ice loss and ocean swell." Nature **558**: 383-389.

Matear, R.J. and Lenton, A. (2018). "Carbon-climate feedbacks accelerate ocean acidification." Biogeosciences **15**(6): 1721-1732.

Meiners, K.M., Arndt, S., Bestley, S., Krumpen, T., Ricker, R., Milnes, M., Newbery, K., Freier, U., Jarman, S., King, R., Proud, R., Kawaguchi, S. and Meyer, B. (2017). "Antarctic pack ice algal distribution: Floe-scale spatial variability and predictability from physical parameters." Geophysical Research Letters **44**(14): 7382-7390.

Mekhaldi, F., McConnell, J.R., Adolphi, F., Arienzo, M.M., Chellman, N.J., Maselli, O.J., Moy, A.D., Plummer, C.T., Sigl, M. and Muscheler, R. (2017). "No Coincident Nitrate Enhancement Events in Polar Ice Cores Following the Largest Known Solar Storms." Journal of Geophysical Research: Atmospheres **122**(21): 11,900-911,913.

Meyer, B., Freier, U., Grimm, V., Groeneveld, J., Hunt, B.P.V., Kerwath, S., King, R., Klaas, C., Pakhomov, E., Meiners, K.M., Melbourne-Thomas, J., Murphy, E.J., Thorpe, S.E., Stammerjohn, S., Wolf-Gladrow, D., Auerswald, L., Götz, A., Halbach, L., Jarman, S., Kawaguchi, S., Krumpen, T., Nehrke, G., Ricker, R., Sumner, M., Teschke, M., Trebilco, R.

and Yilmaz, N.I. (2017). "The winter pack-ice zone provides a sheltered but food-poor habitat for larval Antarctic krill." Nature Ecology and Evolution **1**(12): 1853-1861.
Moreau, S., Penna, A.D., Llort, J., Patel, R., Langlais, C., Boyd, P.W., Matear, R.J., Phillips, H.E., Trull, T.W., Tilbrook, B., Lenton, A. and Strutton, P.G. (2017). "Eddy-induced carbon transport across the Antarctic Circumpolar Current." Global Biogeochemical Cycles **31**(9): 1368-1386.
Mori, M., Corney, S.P., Melbourne-Thomas, J., Klocker, A., Sumner, M. and Constable, A. (2017). "A biologically relevant method for considering patterns of oceanic retention in the Southern Ocean." Progress in Oceanography **159**: 1-12.
Naughten, K.A., Meissner, K.J., Galton-Fenzi, B.K., England, M.H., Timmermann, R., Hellmer, H.H., Hattermann, T. and Debernard, J.B. (2018). "Intercomparison of Antarctic ice-shelf, ocean, and sea-ice interactions simulated by MetROMS-iceshelf and FESOM 1.4." Geoscientific Model Development **11**(4): 1257-1292.
Nihashi, S., Ohshima, K.I. and Tamura, T. (2017). "Sea-Ice Production in Antarctic Coastal Polynyas Estimated From AMSR2 Data and Its Validation Using AMSR-E and SSM/I-SSMIS Data." IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing.
Nitsche, F.O., Porter, D., Williams, G., Cougnon, E.A., Fraser, A.D., Correia, R. and Guerrero, R. (2017). "Bathymetric control of warm ocean water access along the East Antarctic Margin." Geophysical Research Letters **44**(17): 8936-8944.
O'Toole, M., Guinet, C., Lea, M.A. and Hindell, M.A. (2017). "Marine predators and phytoplankton: How elephant seals use the recurrent Kerguelen plume." Marine Ecology Progress Series **581**: 215-227.
Pardo, P.C., Tilbrook, B., Langlais, C., Trull, T.W. and Rintoul, S.R. (2017). "Carbon uptake and biogeochemical change in the Southern Ocean, south of Tasmania." Biogeosciences **14**(22): 5217-5237.
Pellichero, V., Sallée, J.B., Chapman, C.C. and Downes, S.M. (2018). "The southern ocean meridional overturning in the sea-ice sector is driven by freshwater fluxes." Nature Communications **9**(1).
Pfaffhuber, A.A., Lieser, J.L. and Haas, C. (2017). "Snow thickness profiling on Antarctic sea ice with GPR—Rapid and accurate measurements with the potential to upscale needles to a haystack." Geophysical Research Letters **44**(15): 7836-7844.
Pittard, M.L., Galton-Fenzi, B.K., Watson, C.S. and Roberts, J.L. (2017). "Future sea level change from Antarctica's Lambert-Amery glacial system." Geophysical Research Letters **44**(14): 7347-7355.
Priester, C.R., Melbourne-Thomas, J., Klocker, A. and Corney, S. (2017). "Abrupt transitions in dynamics of a NPZD model across Southern Ocean fronts." Ecological Modelling **359**: 372-382.
Raphael, M.N., Holland, M.M., Landrum, L. and Hobbs, W.R. (2018). "Links between the Amundsen Sea Low and sea ice in the Ross Sea: seasonal and interannual relationships." Climate Dynamics: 1-17.
Ratnarajah, L., Nicol, S. and Bowie, A.R. (2018). "Pelagic iron recycling in the Southern Ocean: Exploring the contribution of marine animals." Frontiers in Marine Science **5**(MAR).
Reid, P., Stammerjohn, S., Massom, R., Lieser, J., Barriera, S. and Scambos, T. (2017). "Sea ice extent, concentration and duration [in State of the Climate in 2016]." Bulletin of the American Meteorological Society **98**(8): S163-S166.
Reisinger, R.R., Raymond, B., Hindell, M.A., Bester, M.N., Crawford, R.J.M., Davies, D., de Bruyn, P.J.N., Dilley, B.J., Kirkman, S.P., Makhado, A.B., Ryan, P.G., Schoombie, S., Stevens, K., Sumner, M.D., Tosh, C.A., Wege, M., Whitehead, T.O., Wotherspoon, S. and Pistorius, P.A. (2018). "Habitat modelling of tracking data from multiple marine predators identifies important areas in the Southern Indian Ocean." Diversity and Distributions **24**(4): 535-550.
Rigual Hernandez, A.S., Flores, J.A., Sierro, F.J., Fuertes, M.A., Cros, L. and Trull, T.W. (2018). "Coccolithophore populations and their contribution to carbonate export during an annual cycle in the Australian sector of the Antarctic zone." Biogeosciences **15**(6): 1843-1862.

Rintoul, S.R. (2018). "The global influence of localized dynamics in the Southern Ocean." Nature **558**(7709): 209-218.
Rintoul, S.R., Chown, S.L., DeConto, R.M., England, M.H., Fricker, H.A., Masson-Delmotte, V., Naish, T.R., Siegert, M.J. and Xavier, J.C. (2018). "Choosing the future of Antarctica." Nature **558**(7709): 233-241.
Roberts, J., Galton-Fenzi, B.K., Paolo, F.S., Donnelly, C., Gwyther, D.E., Padman, L., Young, D., Warner, R., Greenbaum, J., Fricker, H.A., Payne, A.J., Cornford, S., Le Brocq, A., van Ommen, T., Blankenship, D. and Siegert, M.J. (2017). "Ocean forced variability of Totten Glacier mass loss." Geological Society, London, Special Publications **461**: 175-186.
Royston, S., Watson, C.S., Legrésy, B., King, M.A., Church, J.A. and Bos, M.S. (2018). "Sea-Level Trend Uncertainty With Pacific Climatic Variability and Temporally-Correlated Noise." Journal of Geophysical Research: Oceans **123**(3): 1978-1993.
Shadwick, E.H., Tilbrook, B. and Currie, K.I. (2017). "Late-summer biogeochemistry in the Mertz Polynya: East Antarctica." Journal of Geophysical Research: Oceans **122**(9): 7380-7394.
Silvano, A., Rintoul, S.R., Peña-Molino, B., Hobbs, W.R., Van Wijk, E., Aoki, S., Tamura, T. and Williams, G.D. (2018). "Freshening by glacial meltwater enhances melting of ice shelves and reduces formation of Antarctic Bottom Water." Science Advances **4**(4).
Snow, K., Rintoul, S.R., Sloyan, B.M. and Hogg, A.M. (2018). "Change in Dense Shelf Water and Adélie Land Bottom Water Precipitated by Iceberg Calving." Geophysical Research Letters **45**(5): 2380-2387.
Stark, J.S., Roden, N.P., Johnstone, G.J., Milnes, M., Black, J.G., Whiteside, S., Kirkwood, W., Newbery, K., Stark, S., Van Ooijen, E., Tilbrook, B., Peltzer, E.T., Berry, K. and Roberts, D. (2018). "Carbonate chemistry of an in-situ free-ocean CO2 enrichment experiment (antFOCE) in comparison to short term variation in Antarctic coastal waters." Scientific Reports **8**(1).
Stenni, B., Curran, M.A.J., Abram, N.J., Orsi, A., Goursaud, S., Masson-Delmotte, V., Neukom, R., Goosse, H., Divine, D., Van Ommen, T., Steig, E.J., Dixon, D.A., Thomas, E.R., Bertler, N.A.N., Isaksson, E., Ekaykin, A., Werner, M. and Frezzotti, M. (2017). "Antarctic climate variability on regional and continental scales over the last 2000 years." Climate of the Past **13**(11): 1609-1634.
Stewart, A.L., Klocker, A. and Menemenlis, D. (2018). "Circum-Antarctic Shoreward Heat Transport Derived From an Eddy- and Tide-Resolving Simulation." Geophysical Research Letters **45**(2): 834-845.
Takahashi, A., Ito, M., Nagai, K., Thiebot, J.B., Mitamura, H., Noda, T., Trathan, P.N., Tamura, T. and Watanabe, Y.Y. (2018). "Migratory movements and winter diving activity of Adélie penguins in East Antarctica." Marine Ecology Progress Series **589**: 227-239.
Thomas, E.R., van Wessem, J.M., Roberts, J., Isaksson, E., Schlosser, E., Fudge, T.J., Vallelonga, P., Medley, B., Lenaerts, J., Bertler, N., van den Broeke, M.R., Dixon, D.A., Frezzotti, M., Stenni, B., Curran, M. and Ekaykin, A.A. (2017). "Regional Antarctic snow accumulation over the past 1000 years." Climate of the Past **13**(11): 1491-1513.
Tison, J.L., Schwegmann, S., Dieckmann, G., Rintala, J.M., Meyer, H., Moreau, S., Vancoppenolle, M., Nomura, D., Engberg, S., Blomster, L.J., Hendrickx, S., Uhlig, C., Luhtanen, A.M., de Jong, J., Janssens, J., Carnat, G., Zhou, J. and Delille, B. (2017). "Biogeochemical Impact of Snow Cover and Cyclonic Intrusions on the Winter Weddell Sea Ice Pack." Journal of Geophysical Research: Oceans **122**(12): 9548-9571.
Treasure, A.M., Roquet, F., Ansorge, I.J., Bester, M.N., Boehme, L., Bornemann, H., Charrassin, J.B., Chevallier, D., Costa, D.P., Fedak, M.A., Guinet, C., Hammill, M.O., Harcourt, R.G., Hindell, M.A., Kovacs, K.M., Lea, M.A., Lovell, P., Lowther, A.D., Lydersen, C., McIntyre, T., McMahon, C.R., Muelbert, M.M.C., Nicholls, K., Picard, B., Reverdin, G., Trites, A.W., Williams, G.D. and Nico De Bruyn, P.J. (2017). "Marine mammals exploring the oceans pole to pole: A review of the meop consortium." Oceanography **30**(2): 132-138.
Trull, T.W., Passmore, A., Davies, D.M., Smit, T., Berry, K. and Tilbrook, B. (2018). "Distribution of planktonic biogenic carbonate organisms in the Southern Ocean south of Australia: A baseline for ocean acidification impact assessment." Biogeosciences **15**(1): 31-49.

van Leeuwe, M., Tedesco, L., Arrigo, K.R., Assmy, P., Campbell, K., Meiners, K.M., Rintala, J.M., Selz, V., Thomas, D.N. and Stefels, J. (2018). "Microalgal community structure and primary production in Arctic and Antarctic sea ice: A synthesis." Elementa Science of the Anthropocene **6**(1): 4.
Wallis, J.R., Kawaguchi, S. and Swadling, K.M. (2018). "Sexual differentiation, gonad maturation, and reproduction of the Southern Ocean euphausiid Thysanoessa macrura (Sars, 1883) (Crustacea: Euphausiacea)." Journal of Crustacean Biology **38**(1): 107-118.
Weldrick, C.K. and Jelinski, D.E. (2017). "Seasonal dynamics in a nearshore isotopic niche and spatial subsidies from multi-trophic aquaculture." Canadian Journal of Fisheries and Aquatic Sciences **74**(9): 1411-1421.
Westwood, K.J., Thomson, P.G., van den Enden, R.L., Maher, L.E., Wright, S.W. and Davidson, A.T. (2018). "Ocean acidification impacts primary and bacterial production in Antarctic coastal waters during austral summer." Journal of Experimental Marine Biology and Ecology **498**: 46-60.
Wojtasiewicz, B., Hardman-Mountford, N.J., Antoine, D., Dufois, F., Slawinski, D. and Trull, T.W. (2018). "Use of bio-optical profiling float data in validation of ocean colour satellite products in a remote ocean region." Remote Sensing of Environment **209**: 275-290.
Wongpan, P., Meiners, K.M., Langhorne, P.J., Heil, P., Smith, I.J., Leonard, G.H., Massom, R.A., Clementson, L.A. and Haskell, T.G. (2018). "Estimation of Antarctic Land-Fast Sea Ice Algal Biomass and Snow Thickness From Under-Ice Radiance Spectra in Two Contrasting Areas." Journal of Geophysical Research: Oceans **123**(3): 1907-1923.
Yang, G., King, R.A. and Kawaguchi, S. (2018). "Behavioural responses of Antarctic krill (Euphausia superba) to CO2-induced ocean acidification: would krill really notice?" Polar Biology **41**(4): 727-732.
Young, D.A., Roberts, J.L., Ritz, C., Frezzotti, M., Quartini, E., Cavitte, M.G.P., Tozer, C.R., Steinhage, D., Urbini, S., Corr, H.F.J., Van Ommen, T. and Blankenship, D.D. (2017). "High-resolution boundary conditions of an old ice target near Dome C, Antarctica." Cryosphere **11**(4): 1897-1911.
Zhang, Y., Feng, M., Du, Y., Phillips, H.E., Bindoff, N.L. and McPhaden, M.J. (2018). "Strengthened Indonesian Throughflow Drives Decadal Warming in the Southern Indian Ocean." Geophysical Research Letters **45**(12): 6167-6175.

Articles in Scholarly Refereed Journals (non-core research*)

Addison, P.F.E., Collins, D.J., Trebilco, R., Howe, S., Bax, N., Hedge, P., Jones, G., Miloslavich, P., Roelfsema, C., Sams, M., Stuart-Smith, R.D., Scanes, P., Von Baumgarten, P. and McQuatters-Gollop, A. (2018). "A new wave of marine evidence-based management: Emerging challenges and solutions to transform monitoring, evaluating, and reporting." ICES Journal of Marine Science **75**(3): 941-952.
Arthur, B., Hindell, M., Bester, M., De Bruyn, P.J.N., Goebel, M.E., Trathan, P. and Lea, M.A. (2018). "Managing for change: Using vertebrate at sea habitat use to direct management efforts." Ecological Indicators **91**: 338-349.
Clements, C.F., Blanchard, J.L., Nash, K.L., Hindell, M.A. and Ozgul, A. (2018). "Reply to 'Whaling catch data are not reliable for analyses of body size shifts." Nature Ecology and Evolution **2**(5): 757-758.
Davies, C.H., Ajani, P., Armbrecht, L., Atkins, N., Baird, M.E., Beard, J., Bonham, P., Burford, M., Clementson, L., Coad, P., Crawford, C., Dela-Cruz, J., Doblin, M.A., Edgar, S., Eriksen, R., Everett, J.D., Furnas, M., Harrison, D.P., Hassler, C., Henschke, N., Hoenner, X., Ingleton, T., Jameson, I., Keesing, J., Leterme, S.C., James McLaughlin, M., Miller, M., Moffatt, D., Moss, A., Nayar, S., Patten, N.L., Patten, R., Pausina, S.A., Proctor, R., Raes, E., Robb, M., Rothlisberg, P., Saeck, E.A., Scanes, P., Suthers, I.M., Swadling, K.M.,

*Non-core research publications are those with authors affiliated with the ACE CRC but that do not address core ACE CRC research

Talbot, S., Thompson, P., Thomson, P.G., Uribe-Palomino, J., Van Ruth, P., Waite, A.M., Wright, S. and Richardson, A.J. (2018). "A database of chlorophyll a in Australian waters." Scientific Data **5**.

Farias, D.R., Hurd, C.L., Eriksen, R.S. and Macleod, C.K. (2018). "Macrophytes as bioindicators of heavy metal pollution in estuarine and coastal environments." Marine Pollution Bulletin **128**: 175-184.

Gastauer, S., Scoulding, B. and Parsons, M. (2017). "Towards acoustic monitoring of a mixed demersal fishery based on commercial data: The case of the Northern Demersal Scalefish Fishery (Western Australia)." Fisheries Research **195**(Supplement C): 91-104.

Gastauer, S., Scoulding, B. and Parsons, M. (2017). "An Unsupervised Acoustic Description of Fish Schools and the Seabed in Three Fishing Regions Within the Northern Demersal Scalefish Fishery (NDSF, Western Australia)." Acoustics Australia.

Hanamseth, R., Barry Baker, G., Sherwen, S., Hindell, M. and Lea, M.A. (2017). "Assessing the importance of net colour as a seabird bycatch mitigation measure in gillnet fishing." Aquatic Conservation: Marine and Freshwater Ecosystems **28**(1): 175-181.

Hibler, W.D., Roberts, A., Heil, P., Proshutinsky, A.Y., Simmons, H.L. and Lovick, J. (2017). "Modeling M2 tidal variability in Arctic Sea-ice drift and deformation." Annals of Glaciology **44**: 418-428.

Hunter, J.R., Woodworth, P.L., Wahl, T. and Nicholls, R.J. (2017). "Using global tide gauge data to validate and improve the representation of extreme sea levels in flood impact studies." Global and Planetary Change **156**: 34-45.

Lei, R., Cheng, B., Heil, P., Vihma, T., Wang, J., Ji, Q. and Zhang, Z. (2018). "Seasonal and Interannual Variations of Sea Ice Mass Balance From the Central Arctic to the Greenland Sea." Journal of Geophysical Research: Oceans **123**(4): 2422-2439.

Nasemann, P., Gault-Ringold, M., Stirling, C.H., Koschinsky, A. and Sander, S.G. (2018). "Processes affecting the isotopic composition of dissolved iron in hydrothermal plumes: A case study from the Vanuatu back-arc." Chemical Geology **476**: 70-84.

Ohata, Y., Toyota, T. and Fraser, A.D. (2017). "The role of snow in the thickening processes of lake ice at Lake Abashiri, Hokkaido, Japan." Tellus A: Dynamic Meteorology and Oceanography **69**(1): 1391655.

Oliver, E.C.J., Benthuysen, J.A., Bindoff, N.L., Hobday, A.J., Holbrook, N.J., Mundy, C.N. and Perkins-Kirkpatrick, S.E. (2017). "The unprecedented 2015/16 Tasman Sea marine heatwave." Nature Communications **8**.

Rolison, J.M., Stirling, C.H., Middag, R., Gault-Ringold, M., George, E. and Rijkenberg, M.J.A. (2018). "Iron isotope fractionation during pyrite formation in a sulfidic Precambrian ocean analogue." Earth and Planetary Science Letters **488**: 1-13.

Springer, A.M., Van Vliet, G.B., Bool, N., Crowley, M., Fullagar, P., Lea, M.A., Monash, R., Price, C., Vertigan, C. and Woehler, E.J. (2018). "Transhemispheric ecosystem disservices of pink salmon in a Pacific Ocean macrosystem." Proceedings of the National Academy of Sciences of the United States of America **115**(22): E5038-E5045.

Stone, K.A., Solomon, S., Kinnison, D.E., Pitts, M.C., Poole, L.R., Mills, M.J., Schmidt, A., Neely, R.R., III, Ivy, D., Schwartz, M.J., Vernier, J.P., Johnson, B.J., Tully, M.B., Klekociuk, A.R., König-Langlo, G. and Hagiya, S. (2017). "Observing the Impact of Calbuco Volcanic Aerosols on South Polar Ozone Depletion in 2015." Journal of Geophysical Research: Atmospheres **122**(21): 11,862-811,879.

Wan, X.S., Sheng, H.X., Dai, M., Zhang, Y., Shi, D., Trull, T.W., Zhu, Y., Lomas, M.W. and Kao, S.J. (2018). "Ambient nitrate switches the ammonium consumption pathway in the euphotic ocean." Nature Communications **9**(1).

Yan, X.i., Xu, M.N., Wan, X.S., Yang, J.-Y.T., Trull, T.W., Dai, M. and Kao, S.-J. (2017). "Dual Isotope Measurements Reveal Zoning of Nitrate Processing in the Summer Changjiang (Yangtze) River Plume." Geophysical Research Letters **44**(24): 12,289-212,297.

Appendix 2– ACE CRC PhD students 2017-2018

Commenced in 2017/18 (note - as the CRC will end before PhD completion, supervision will be supported by UTAS post ACE CRC).

Name	Commencement Date	Status	Research Program	Project Title	Research Organisation	Country of Origin	Expected Completion Date
1. Arena, Enrico	27/11/2017	FT	Oceans & Cryosphere	Fingerprinting the Southern Hemisphere's Ocean Contribution to Global Changes in Steric Sea Level	UTAS	Italy	November 2021
2. Meijer, Jan Jaap	01/08/2017	FT	Oceans & Cryosphere	An Observational Study of the Role of Standing Meanders in Slowing the ACC and Transporting Heat to Antarctica	UTAS	The Netherlands	August 2021
3. Glor, Cheryl	15/09/2017	FT	Oceans & Cryosphere	Investigation of Sea Salt Variability and Volcanic Deposition at Aurora Basin North, East Antarctica – Impacts and Influence on Climate Variability over the Past 2000 Years	UTAS	United States of America	September 2021
4. Woods, Bree	30/11/2017	FT	Carbon & Ecosystems	Understanding the Energy Pathways through Southern Ocean Mesopelagic Communities	UTAS	Australia	November 2021
5. Halfter, Svenja	29/11/2017	FT	Carbon & Ecosystems	The Ocean's Biological Pump: Mesozooplankton controls on particle export	UTAS	Germany	November 2021
6. Latour, Pauline	27/04/2018	FT	Carbon & Ecosystems	The Biogeochemistry of Trace Elements in the Australian Sector of the Southern Ocean: GEOTRACES-SR3 repeat	UTAS	France	April 2022

***FT – full-time; PT – part-time**

Name	Commencement Date	Status	Research Program	Project Title	Research Organisation	Country of Origin	Expected Completion Date
				section from Tasmania to Antarctica			
7. Melvin, Jessica	01/03/2018	FT	Carbon & Ecosystems	Effect of Ocean Acidification on Physiology and Growth of Antarctic Krill	UTAS	Australia	March 2022
8. Udy, Danielle	04/06/2018	FT	Oceans & Cryosphere	Extending the Palaeohydroclimatology Record of Eastern Australia to Underpin Efficient Water Management by Understanding Long Term Climate Variability	UTAS	Australia	June 2022
9. Smith, Abigail	01/06/2018	FT	Carbon & Ecosystems	Influence of Marine Animals on the Biological Carbon Pump in the Southern Ocean	UTAS	Australia	June 2022

Completed

Name	Commencement Date	Status	Research Program	Project Title	Research Organisation	Country of Origin	Expected Completion Date
1. Alexander, Kaitlin	September 2014	FT	Oceans & Cryosphere	Response of sub-ice shelf circulation to 21st century projections of climate change	University of New South Wales	Canada	Graduated August 2017
2. Durand, Axel	03/04/2013	FT	Carbon & Ecosystems	Ocean Deoxygenation, a Paleo Proxy Perspective	UTAS	France	Graduated August 2017
3. Lago, Veronique	06/04/2011	FT	Oceans & Cryosphere	Testing of climate models and sea level rise projections using observations of ocean heat uptake	UTAS	Canada	Graduated August 2017

Name	Commencement Date	Status	Research Program	Project Title	Research Organisation	Country of Origin	Expected Completion Date
4. Janssens, Julie	06/09/2012	FT	Carbon & Ecosystems	Incorporation Mechanisms of Organic Matter and Iron into Sea Ice	UTAS	Belgium	Graduated August 2017
5. Labrousse, Sara	02/09/2014	FT	Carbon & Ecosystems	Foraging Ecology of Male and Female Elephant Seals in the Sea-Ice Zone: Role of the physiography, hydrological factors, and sea-ice condition	UTAS - Cotutelle	France	Graduated August 2017
6. Michael, Pam	04/02/2013	FT	Carbon & Ecosystems	Potential impacts of climate change on the dynamics and distribution of tuna, major industrial pelagic longline fleets and consequent interactions with threatened albatrosses: a first application to the Indian Ocean	UTAS	Australia	Graduated August 2017
7. Ratnarajah, Lavenia	01/12/2013	FT	Carbon & Ecosystems	Effect of natural iron fertilisation by krill and whales on the Southern Ocean carbon cycle	UTAS	Malaysia	Graduated August 2017
8. Roden, Nick	14/03/2011	PT	Carbon & Ecosystems	Acidification and Carbonate Chemistry of Shelf Waters in the Australian Antarctic Territory	UTAS	Australia	Graduated August 2017

Withdrawn

Name	Commencement Date	Status	Research Program	Project Title	Research Organisation	Country of Origin	Expected Completion Date
1. Freyer, Julien	01/03/2016	FT	Carbon & Ecosystems	Comparative diving physiology and ecology across the Southern Ocean marine predators	UTAS	France	September 2019
2. Polanowski, Andrea	03/10/2011	PT	Carbon & Ecosystems	Mechanisms for Sex Determination in Antarctic Krill	UTAS	Australia	April 2021
3. Thornton, David	10/08/2015	PT	Oceans & Cryosphere	Evidence of carbon cycle changes from trace gas indicators in polar ice	UTAS	Australia	August 2020

Continuing (note - a number commenced prior to the current funding of the ACECRC and others will complete post-ACE CRC)

Name	Commencement Date	Status	Research Program	Project Title	Research Organisation	Country of Origin	Expected Completion Date
1. Abdul Salam, Syed	9/06/2017	FT	Oceans & Cryosphere	The temperature distribution within the East Antarctic Ice Sheet	UTAS	Pakistan	December 2020
2. Abhishek Savita, Abhishek	5/06/2017	FT	Oceans & Cryosphere	Global and regional sea level sensitivity to changing ocean water mass properties and circulation processes	UTAS	India	December 2020
3. Aflenzer, Helene	18/04/2016	FT	Carbon & Ecosystems	Impact of ocean acidification on the availability and toxicity of trace elements and nutrients	UTAS	Austria	October 2019

Name	Commencement Date	Status	Research Program	Project Title	Research Organisation	Country of Origin	Expected Completion Date
4. Baird-Bower, Debbie	08/04/2013	FT	Carbon & Ecosystems	Demographic Responses of Antarctic Fur Seals to Environmental Variability	UTAS	United Kingdom	April 2017 (submitted)
5. Goedegebuure, Merel (previously Bedford, Merel)	01/03/2014	FT	Carbon & Ecosystems	Representing Southern Ocean predators in end-to-end ecosystem models using individual-based modelling	UTAS	The Netherlands	September 2017 (submitted)
6. Black, James	28/08/2014	PT	Carbon & Ecosystems	Measuring impacts of ocean acidification on biological communities in Antarctica: an in-situ experiment and laboratory exploration of the mechanisms of community	UTAS	Australia	March 2018
7. Blanche, Bella	08/02/2016	FT	Oceans & Cryosphere	Detecting human influence in global ocean salinity patterns	UTAS	France	August 2019
8. Buchanan, Pearse	01/11/2014	FT	Oceans & Cryosphere	Ocean Deoxygenation: A paleo-modelling perspective	UTAS	Australia	May 2018 (submitted)
9. Campbell, Sharon	1/03/2017	FT	Climate Futures	Understanding current and future impacts of extreme heat events on the health of vulnerable Tasmanians	UTAS	Australian	September 2020
10. Cleeland, Jaimie	20/05/2013	FT	Carbon & Ecosystems	Macquarie Island's Albatrosses: A comprehensive assessment of population and demographic status and trends and the environmental and anthropogenic	UTAS	Australia	July 2017 (submitted)

Name	Commencement Date	Status	Research Program	Project Title	Research Organisation	Country of Origin	Expected Completion Date
11. Cimoli, Emiliano	31/03/2016	FT	Oceans & Cryosphere	Hyperspectral remote sensing of Antarctic sea ice algae and benthos using AUV	UTAS	Italy	September 2019
12. Cranenburgh, Andrea	01/03/2016	FT	Oceans & Cryosphere	How do standing meanders break the ACC?	UTAS	Australia	September 2019
13. Cyriac, Ajitha	18/11/2015	FT	Oceans & Cryosphere	Eastward flows, ocean mixing and air-sea interaction in the Southeast Indian Ocean	UTAS	India	June 2019
14. Deppeler, Stacy	15/10/2013	FT	Carbon & Ecosystems	Effects of Elevated pCO2 on the Productivity of Marine Microbes and the Remineralisation of Nutrients in Coastal Antarctic Waters	UTAS	Australia	April 2017 (submitted)
15. Dias, Fabio	24/08/2015	FT	Oceans & Cryosphere	Testing of Climate Models and Sea Level Rise Projections using Observations of Ocean Heat Uptake	UTAS	Brazil	February 2019
16. Duprat, Luis	1/08/2016	FT	Carbon & Ecosystems	Role of sea ice as a source of bio-available iron to Antarctic surface waters	UTAS	Brazil	March 2020
17. Ericson, Jessica	15/10/2015	FT	Carbon & Ecosystems	Using Signature Lipid Analysis to Understand the Biology and Ecology of Antarctic Krill (*Euphausia superba*)	UTAS	New Zealand	April 2019
18. Evans, Eleri	08/07/2015	FT	Oceans & Cryosphere	Processes Controlling Iceberg Calving Rates Around Antarctic Margins	UTAS	Australia	January 2019

Name	Commencement Date	Status	Research Program	Project Title	Research Organisation	Country of Origin	Expected Completion Date
19. Gamble Rosevear, Madeleine	01/02/2016	FT	Oceans & Cryosphere	Fine scale ocean processes driving the basal melting of ice shelves	UTAS	Australia	August 2019
20. Genovese, Cristina	29/11/2016	FT	Carbon & Ecosystems	Role of organic ligands in the distribution of iron in polar waters	UTAS	Italy	June 2020
21. Hancock, Alice	1/1/2016	FT	Carbon & Ecosystems	Effects of ocean acidification on associations among Antarctica and SO marine microbes	UTAS	Australia	July 2019
22. Hamilton, Vicki	24/07/2012	PT	Carbon & Ecosystems	Energetic Variability in Sperm Whales and Relationships with the Marine Environment	UTAS	Australia	December 2017 (extended)
23. Hellessey, Nicole	01/11/2015	FT	Carbon & Ecosystems	Seasonal lipid changes in Antarctic krill in relation to Climate Change	UTAS	Australia	June 2019
24. Hodgson-Johnston, Indiah	21/10/2013	FT	Carbon & Ecosystems	Beyond the Bases? Applying Contemporary Principles of International Law to Australian Sovereignty in Antarctica	UTAS	Australia	April 2017 (submitted)
25. Hollman, Hannes	1/03/2017	FT	Oceans & Cryosphere	A geophysical investigation of the subglacial environment and its role in the evolution of ice dynamics	UTAS	Germany	September 2020
26. Holmes, Thomas	01/04/2014	FT	Carbon & Ecosystems	The impact of hydrothermal vents on trace metal biogeochemistry in the Southern Ocean	UTAS	Australia	October 2017

Name	Commencement Date	Status	Research Program	Project Title	Research Organisation	Country of Origin	Expected Completion Date
27. Huneke, Wilma	19/10/2015	FT	Oceans & Cryosphere	Quantifying Key Physical Processes Responsible for Ocean Warming under Antarctic Ice Shelves	UTAS	Germany	January 2019
28. Jackson, Andrew	01/03/2015	FT	Carbon & Ecosystems	Who Saved Antarctica?	UTAS	Australia	September 2018
29. Jansen, Jan	01/10/2014	FT	Carbon & Ecosystems	Modelling biodiversity in the Southern Ocean and Antarctica using sparse data	UTAS	Germany	April 2019
30. Kelly, Paige	01/08/2015	FT	Carbon & Ecosystems	Climate Change and Sea Ice Habitats: Modelling effects from plankton to penguins	UTAS	Australia	February 2019
31. Kennedy, Fraser	18/08/2015	FT	Carbon & Ecosystems	Using experimental sea ice tanks and micro sensors to investigate sea ice microbial ecology	UTAS	New Zealand	February 2019
32. Lee, Shi Hong	15/12/2012	FT	Carbon & Ecosystems	Impact of Climate Change on Physiological and Behavioural Responses of Coastal Microphytobenthos	UTAS	Malaysia	March 2017
33. Libaros, Damien	28/08/2015	FT	Oceans & Cryosphere	Determining changes in sea level around Antarctica	UTAS	France	February 2019
34. McCormack, Stacey	22/07/2015	FT	Carbon & Ecosystems	Energy Flow in Southern Ocean Ecosystems: Comparing mass balance and size-based approaches	UTAS	Australia	January 2019
35. Mori, Mao	01/12/2014	FT	Carbon & Ecosystems	Modelling ocean transport of key species in the Indian sector of the Southern Ocean	UTAS	Japan	June 2018 (submitted)

Name	Commencement Date	Status	Research Program	Project Title	Research Organisation	Country of Origin	Expected Completion Date
36. Patel, Ramkrushnbhai	02/03/2016	FT	Oceans & Cryosphere	The physical and bio-optical structure of Southern Ocean eddies in observations and models	UTAS	India	September 2019
37. Pavez, Cassandra	10/04/2017	FT	Carbon & Ecosystems	Understanding distribution behaviour and morphology of Antarctic krill by using the data collected by scientific observers on krill fishing vessels	UTAS	Australia	October 2020
38. Peel, Samantha	27/01/2015	FT	Carbon & Ecosystems	Statistical Issues for Mapping Biodiversity in the Southern Ocean	UTAS	Australia	July 2018
39. Perez-Tribouillier, Habacuc	07/10/2015	FT	Carbon & Ecosystems	Quantifying Protactinium, Thorium and Neodymium Isotopes in Southwest Pacific Waters: Elucidating the Oceanographic Controls on these Tracers of Circulation, Productivity and Dust Input	UTAS	Mexico	January 2019
40. Perron, Morgane	02/05/2016	FT	Carbon & Ecosystems	Natural iron fertilisation of oceans around Australian linking terrestrial aerosols to marine biogeochemistry	UTAS	France	November 2019
41. Plummer, Christopher	01/05/2010	FT	Oceans & Cryosphere	Holocene Climate and Environmental Indicators from Trace Chemistry of Law Dome Ice Core, Antarctica	UTAS	Australia	February 2018 (submitted)
42. Rathore, Saurabh	31/10/2016	FT	Oceans & Cryosphere	The impact of recent Indian Ocean warming on the circulation, watermass	UTAS	India	May 2020

Name	Commencement Date	Status	Research Program	Project Title	Research Organisation	Country of Origin	Expected Completion Date
				distribution and air-sea interaction			
43. Richter, Ole	02/05/2016	FT	Oceans & Cryosphere	Tidal melting of Antarctic Ice Shelves since last glacial maximum	UTAS	Germany	November 2019
44. Schroeter, Ben	01/02/2016	FT	Oceans & Cryosphere	Towards improved modelling of the high southern latitudes	UTAS	Australia	August 2019
45. Schroeter, Serena	30/03/2015	FT	Oceans & Cryosphere	The response of Antarctic sea ice to anthropogenic climate change, from model and satellite observations	UTAS	Australia	September 2018
46. Sellers, Ben	31/07/2015	PT	Carbon & Ecosystems	Determining Predator Prey Relationships of Killer Whales Within Distinct Areas of the Southern Ocean Using Biochemical Analytical Tools (Signature Fatty Acids and Stable Isotopes)	UTAS	Australia	January 2019
47. Semolini Pilo, Gabriela	15/12/2013	FT	Oceans & Cryosphere	Eddies Tridimensional Structure and their Role in Oceanic Mass and Heat Distribution	UTAS	Brazil	June 2017 (submitted)
48. Silvano, Allessandro	05/05/2015	FT	Oceans & Cryosphere	Observations of Ocean - Ice Shelf Interaction at the Totten Glacier	UTAS	Italy	November 2018
49. Sow, Swan	20/09/2015	FT	Carbon & Ecosystems	Microbial Oceanography of the Different Water Masses of the Southern Ocean	UTAS	Malaysia	March 2019
50. Strezelec, Michal	31/05/2016	FT	Carbon & Ecosystems	Source characterisation of atmospheric trace metal deposition around Australia	UTAS	Poland	September 2019

Name	Commencement Date	Status	Research Program	Project Title	Research Organisation	Country of Origin	Expected Completion Date
51. Subramaniam, Roshni	11/07/2016	FT	Carbon & Ecosystems	Food web modelling for the Indian sector of the Southern Ocean	UTAS	New Zealand	December 2020
52. Tonnard, Manon	01/10/2014	FT	Carbon & Ecosystems	The biogeochemical cycles of trace metals: distributions and speciation in the ocean and co-impact on the phytoplankton (GEOVIDE)	UTAS/University of Bretagne - cotutelle	France	April 2018 (submitted)
53. Ward, Delphine	01/10/2014	FT	Carbon & Ecosystems	Evaluating the likelihood of critical transitions in Southern Ocean ecosystems	UTAS	Australia	April 2018
54. Wallis, Jake	31/03/2016	FT	Carbon & Ecosystems	Impacts of ocean acidification on Southern Ocean lower-thropic food pathways	UTAS	Australia	September 2019
55. Wariji, Doreen	1/1/2016	FT	Oceans & Cryosphere	High resolution modelling of the retreat of the East Antarctic ice sheet since last glacial maximum	UTAS	India	July 2019
56. Weldrick, Christine	1/12/2015	FT	Carbon & Ecosystems	Mapping Planktonic Trophic Pathways Through the Sea Ice Zone	UTAS	Canada	June 2019
57. Yang, Luwei	14/10/2015	FT	Oceans & Cryosphere	Internal Waves and Mixing in the Southern Ocean	UTAS	China	April 2019
58. Zhao, Chen	13/10/2014	FT	Oceans & Cryosphere	Ice mass unloading and bedrock response in the southern Antarctic Peninsula	UTAS	China	April 2018