



ANTARCTIC CLIMATE & ECOSYSTEMS COOPERATIVE RESEARCH CENTRE

2016/17 Annual Report



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Annual Report 2016-17

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1 Executive Summary

1.1 Achievements

Research

The ACECRC made strong progress against all of its research goals in 2016/17. Although some milestones were only partly achieved, mainly due to vessel scheduling, all deliverables for the CRC term remain on track, with the outstanding 2016/17 milestones to be completed in 2017/18, and remaining milestones not impacted.

Our scientists had a successful Antarctic field season in 2016/17, particularly the voyage on the RSV Aurora Australis, which was able to take new measurements near the Totten Glacier which provided further evidence that warm water reaches the neighbouring ice shelves and drives rapid basal melt.

The first measurements of basal melt rates of the Totten Glacier were also achieved, as a result of deploying phase sensitive radars and GPS units at six locations to track ice motion and basal melt.

High-resolution modelling is making significant gains in understanding of sea ice–ocean–ice shelf interactions in East Antarctica, together with the implications on pathways of dense shelf water and factors responsible for the recent Antarctic sea ice minimum. Work during the year also included ground-breaking new satellite-based work on fast ice that included links to sea ice production.

Ice core projects have produced records of Antarctic climate variability over the last 2000 years, and snow accumulation rate variability over the last 1000 years. These projects are the culmination of national and international collaborative efforts that evolved from global temperature reconstruction work, initially led by ACECRC and AAD, which have maintained continuing lead roles. This work has determined the onset of anthropogenic warming over the land and oceans to be in the 1830s, significantly earlier than first thought.

Work continued on the two longest running signature ACECRC projects, the SR3 repeat hydrographic section from Tasmania to Antarctica, and the Southern Ocean time series, both of which are examining the role of the Southern Ocean in moderating climate change.

Investigations on potential tipping points on Southern Ocean ecosystems from increasing ocean warming and acidification was conducted in both shipboard and laboratory-based experiments, and an overall assessment of change in these habitats in general is nearing publication.

In 2016/17, our researchers published a total of 5 book chapters and 146 articles in scholarly refereed journals. A further 27 articles were submitted to scholarly refereed journals or are in press at the time of reporting.

Education and Training

During the reporting period, 60 (FTE) students were involved in PhD studies related to the ACECRC, including 9 commencing students. There were also 13 completions. Of the 13 PhD students that graduated during the reporting period, 6 are in post-doctoral positions at partner institutions. A further 7 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.

Utilisation

During the reporting period, the ACECRC participated in a variety of important outreach events, including the 2016 ACECRC Symposium, a Canberra Research User Forum, the CRC Showcase, and a variety of educational events such as the popular Festival of Bright Ideas in Hobart.

The ACECRC Symposium featured presentations from end-users and researchers around the broad theme of emerging Australian climate science priorities as well as showcasing recent science highlights from each of the ACECRC research projects. Over 180 individuals registered for the event, including staff members, partner agency representatives, departmental staff and MPs.

The Research User Forum, held at the Shine Dome in Canberra in April 2017, at which researchers presented consultation drafts of two new *Position Analysis* publications:

- The 'Antarctic ice sheet and sea level' position analysis provides a science overview assessing the vulnerability of the Antarctic ice sheet and the need to provide more reliable projections of global mean sea level and its geographical distribution.
- The 'Managing Southern Ocean Ecosystems' position analysis provides an update on the latest developments in research into the impacts on climate change on Southern Ocean ecosystems, explaining the techniques and tools capable of reflecting the complexity of climate change impacts on Southern Ocean ecosystems.

The ACECRC also participated in the 2017 CRC Showcase for the CRC Association's Annual Conference ('Collaborate | Innovate') in the Great Hall of Parliament House in Canberra, which provided an opportunity for elected representatives, senior departmental staff and foreign embassy staff to learn about current CRC research activities. The ACECRC and AAD jointly funded irradiation of three new demonstration ice cores, as the primary focus of the display.

Collaboration

ACECRC 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 ACECRC collaborates with 100 domestic and international organisations. Of these, there are 27 Australian, 3 New Zealand, 9 Asian, 24 North American, 1 South American, and 36 European.

In particular during the year, the ACECRC hosted or led a number of major international workshops and other similar events.

- Along with the Antarctic Gateway Partnership and IMAS, it successfully hosted the Asia-Pacific Regional Ocean Modelling System Workshop, attended by nearly 100 international scientists.

- Hosted by CRC partner, AWI, ACE scientists led a highly successful international workshop to further develop a strategy for observing the oceans under Antarctic sea ice and ice shelves.

Awards and Special Commendations

The paper led by Dr Steve Rintoul proving that warm ocean waters were driving melting of the ice shelf from below, resulted in the ACE CRC and CSIRO team being selected as finalists for the Eureka Prize in Environmental Research. This work was first funded by the Antarctic CRC in 1991 and supported through every funding round.

Dr Delphine Lannuzel was one of only 12 leading researchers across Australia to be recognised for her outstanding research achievements in chemical and biological oceanography, at the inaugural Women in Research Citation Awards. The national citation awards are designed to encourage greater gender equity in research and honour the outstanding achievements of early to mid-career women researchers in Australia across all fields of research in science, social sciences and the humanities.

ACE CRC postdoc Dr Stephanie Downes was awarded the Tasmanian Young Tall Poppy of the Year Award in October 2016. This award was in recognition of Dr Downes' excellent oceanographic research as well as her leading role in science communication and public engagement.

Dr Rebecca Harris has been awarded a prestigious Humboldt Fellowship and is spending 14 months in Germany, which commenced in January 2017.

Dr Jess Melbourne-Thomas was recognised as a 'Superstar of SIEM' by Science and Technology Australia and appointed as a Lead Author of the IPCC's special report on Oceans and Cryosphere in a Changing Climate. Prof Nathan Bindoff (UTAS/ACE) has been appointed as a Coordinating Lead Author of the same report.

Prof Nathan Bindoff also received the University of Tasmania Distinguished Service Medal. The Distinguished Service Medal was established in 2004 to recognise exceptional and sustained contributions by staff to the achievement of the goals of the University of Tasmania.

Dr Steve Rintoul and the ACE/CSIRO Oceans team were finalists in the Eureka Awards for their work observing Southern Ocean change culminating in the recent Totten Glacier findings that warm water is reaching the underside of the glacier.

Dr Andrew Constable received the Commonwealth Department of Environment and Energy Australia Day Award in February 2017 for his thirty-one years of service to CCAMLR.

Dr Tom Remenyi was a finalist at the Early Career Researcher Showcase as part of the CRC Association annual symposium.

The CEO has instituted an annual "CEO Award for Excellence". There were two recipients of this award in 2016: Dr Rowan Tebilo and Dr Diana Davies. Dr Tebilo was also accepted into the 2017 Tasmanian Leadership Development program.

Special acknowledgement of staff is also made at staff meetings and staff forums for outstanding work.

Staff appointments

During the reporting period, the ACECRC recruited the following people:

Ruth Erikson	Phytoplankton Ecologist
Sven Gastauer	Southern Ocean Acoustician
Christopher Plummer	Ice Core Palaeoclimatologist
Lavenia Ratnarajah	Climate Research Fellow/Microbial Ecologist
Rick Smith	Marine Spatial Analyst
Cathryn Wynn-Edwards	Marine Analytical Chemist

Also during the reporting period, Dr Adam Tevewrow and Dr Rowan Tebilo were promoted to an academic level B and Dr Tebilo was also accepted into the 2017 Tasmania Leadership Development program.

There were no major capital costs for this reporting period.

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

1.2 Risks and Impediments

The ACECRC management team has developed an organisational risk register to capture the different risks to the ACECRC and to the delivery of the ACECRC milestones. The ACECRC 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 ACECRC. Over the reporting period, the overall risk profile of the ACECRC continued to improve, with the majority of risks are now at, or better than, target. The exceptions to this are:

- Future beyond current term; and
- Loss of key people.

Both of these risks are being impacted by the uncertainty around CRC funding term finishing in June 2019. Actions being taken to mitigate these risks include development of a proposal for a new centre, and close management of staff contract terms and career plans.

During the year, we continued to strengthen workplace health and safety, with an independent audit undertaken during the year, which found compliance in all categories. Actions over the past year have focused on risk management for fieldwork and continued improvement in laboratory processes.

1.3 Impacts

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

2 Performance against activities

The ACECRC made strong progress against all of its research goals in 2016/17. Although some milestones were only partly achieved, mainly due to vessel scheduling, all deliverables for the CRC term remain on track, with the outstanding 2016/17 milestones to be completed in 2017/18, and remaining milestones not impacted.

The ACECRC 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 Southern Ocean stores more anthropogenic heat and carbon dioxide than any other latitude band but is changing rapidly: it is warming, freshening, decreasing in oxygen, acidifying, and the Antarctic Bottom Water layer has contracted by 50% since 1970. Much of this is known as a result of sustained research by the ACECRC since 1991. The ability of the Southern Ocean to continue to take up heat and carbon dioxide, and thereby slow the rate of climate change on land, is uncertain. Research shows that heat and carbon uptake is localised in subduction "hot spots" which may be sensitive to climate change. Melt of glacial ice by a warming ocean is more important to future sea level rise than recognised previously, but the future response of the Antarctic ice sheet to ocean warming is not known. Many of the changes observed in the Southern Ocean are likely to be caused by human drivers (e.g. ozone, greenhouse), but the scale of human influence is yet to be quantified from attribution studies.

Research Activities 2016/17

Major highlights in 2016/17 include the discovery that parts of East Antarctica are more exposed to warm ocean waters than thought, and hence more likely to contribute to future sea level rise; new insights into the processes driving change in the ocean; and a highly successful oceanographic expedition to the Totten, Mertz, and Ninnis ice shelves.

A voyage on the *RSV Aurora Australis* in 2016/17 achieved several important milestones. New measurements near the Totten Glacier provided further evidence that warm water reaches the neighboring ice shelves and drives rapid basal melt. At the Mertz Glacier, observations were made to track the ongoing response of the ocean to the major ice berg calving event in 2010, and to evaluate the impact on melt of the Mertz Glacier Tongue. The voyage also collected the first oceanographic measurements near the Ninnis Ice Shelf and discovered a deep canyon in the region. Finally, measurements were collected in deep water along the “SR3” hydrographic line. This section, occupied by the ACECRC since 1991, is one of the longest deep ocean time series in the Southern Ocean. The data will be used to document changes in Antarctic Bottom Water.

Due to scheduling and vessel changes, measurements of the remainder of the SR3 section will be undertaken next summer (17-18) on the *RV Investigator*. This voyage is scheduled to depart January 2018. The voyage will now be combined with a study of Southern Ocean clouds (CAPRICORN) led by the Bureau of Meteorology. This is a good opportunity to lay the foundation for future collaboration on the critical issue of biases in how climate models represent Southern Ocean clouds – a bias that affects global aspects of the model simulations/projections. The first array of deep Argo floats in the Southern Ocean will be deployed on the voyage, in collaboration with France, Japan and the USA. In addition, scientists from R2.1 will collect measurements of trace elements and isotopes.

A paper led by Dr Steve Rintoul in *Science Advances* (Ocean heat drives rapid basal melt of the Totten Ice Shelf), shed new light on the vulnerability of the East Antarctic ice sheet to ocean heat, which is one of the biggest unknown factors for global sea level rise projections. This paper used measurements collected on the 2014-2015 *RSV Aurora Australis* voyage to prove the hypothesis that warm ocean waters were driving melting of the ice shelf from below. The results showed that, on an area-averaged basis, the Totten Ice Shelf has the highest basal melt rate among Eastern Antarctic ice shelves.

For this work, the Southern Ocean Team from CSIRO and the ACECRC were selected as finalists for the Eureka Prize in Environmental Research for studying the vulnerability of the Totten Glacier to warm ocean waters and the implications for future sea level. Team members included Dr Steve Rintoul, PhD student Alessandro Silvano, Dr Esmee van Wijk, Dr Beatriz Peña-Molino and Dr Mark Rosenberg.

Good progress has been made on analysis of global ocean changes in temperature and salinity. Changes over the well-measured recent decade show intriguing differences between the Atlantic, Indian and Pacific basins. Teasing out the processes responsible for the temporal and spatial variations in ocean heat content will provide the mechanistic understanding needed to better interpret records and projections of longer-term change.

ACECRC scientists led a highly successful international workshop to further develop a strategy for observing the oceans under Antarctic sea ice and ice shelves, hosted by ACECRC partner AWI in Bremerhaven during June 2017. Dr Esmee van Wijk led the successful proposal to the Partnership for Observations of the Global Ocean (POGO) that supported the workshop.

A paper using stable oxygen isotopes to quantify changes in glacial meltwater input at the Mertz Glacier, led by one of our Japanese partners in Hokkaido, was accepted for publication in the Journal of Geophysical Research – Oceans.

Prof Nathan Bindoff attended the IPCC scoping meeting for the Special Report on Oceans and Cryosphere and also attended the G7 Meeting on Sustainable Ocean Observations, drawn from the G7 Tsukuba communique.

Mr Jordan Brook received the R1.1 summer internship to undertake a desktop study of methods employed to study the biological effects of multiple oceanic stressors under supervision of Drs Stephanie Downes and Clothilde Langlais. A paper based on his work has been accepted for publication in the Journal of Physical Oceanography.

ACE CRC hosted Prof Marilyn Raphael (UCLA), with support from the UIAS competitive visiting scholars scheme. During Prof Raphael's visit, she collaborated with researchers in R1.1 on an analysis of the seasonal pattern of trends in Antarctic sea ice and their drivers. We also welcomed several new PhD students. Patel Ramkrushnbaicommenced on a project researching the physical and bio-optical structure of southern ocean eddies in observations and models. In addition, Saurabh Rathore commenced on a project looking at the impact of recent Indian Ocean warming on the circulation, water mass distribution and air-sea interaction in the Indian Ocean.

Research Project 1.2 Ocean Forced Evolution of the Antarctic Ice Sheet

Project Summary

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.

Present understanding of the processes governing ice sheet mass loss is poor and the rate of loss under any given future climate scenario is uncertain. Increasingly detailed observations over the last decade have revealed the dynamic nature of ice sheet margins, where rapid changes can be evident on short time scales. A number of external triggers and physical processes have been linked with these changes, with the primary driver thought to be changes in ocean forcing. Ice shelf basal melt rates are controlled by the state of the ocean within the sub-ice-shelf cavities, and ultimately by the transfer of heat within the ocean provided by a complex interplay between the transport of water from the deep ocean and the air-sea fluxes over the continental shelf. The cross-shelf pathways and variability of the oceanic heat supply to the margin of the grounded ice sheet are unknown, and may also be part of interannual variability. Increased melting at the base of ice shelves can lead to a reduction in the thickness and length of ice shelves, potentially reducing the irbuttressing effect. This increases stresses at the grounding line, causing faster ice flow and thinning in the grounded portion of the marine-terminating glaciers and consequently leading to grounding line retreat. Positive feedbacks associated with bed topography may further enhance shelf-melting driven retreat where grounded ice rests on an overdeepened bed, and a slight retreat of the grounding line causes it to move into deeper water.

East Antarctica holds far more sea level rise potential than West Antarctica and Greenland combined. Estimates indicate that the West Antarctic Ice Sheet holds 3.4 meters of sea level rise in regions grounded below sea level, while the larger East Antarctic Ice Sheet holds 19.2 meters of sea level in regions where the ice sheet is grounded below sea level. The shape of these deep bedrock basins under the ice may make parts of East Antarctica susceptible to runaway grounding retreat through the same feedback process that has been associated with Pine Island Glacier and numerous Greenland outlet glaciers. Whether and when such a retreat could be triggered is currently unclear, and key datasets (bedrock and bathymetry, water column structure, ice thinning rates and subglacial context) are sparse and incomplete. These knowledge gaps, and the potential Antarctic input to future sea level, motivate this project and provide the impetus for continued collection of key observations in East Antarctica. They also justify further development of numerical models of the Antarctic ice sheet, and its interaction with the climate system, to improve projections of future sea level rise.

Research Activities 2016/17

The summer field season for R1.2 was very successful with the ice shelf team, led by Ben Galton-Fenzi, deploying phase sensitive radars and GPS units at six locations on the Totten Glacier to track ice motion and basal melt. These are the first measurements of basal melt rates of the Totten Glacier. The six towers deployed will be revisited in the 2017/18 field season with seismic surveys also expected to proceed in collaboration with the Antarctic Gateway Partnership.

At the Sørskal Glacier, near Australia's Davis research station, ACECRC researchers and Dr Christian Schoof from the University of British Columbia, have deployed cameras to take photos every 2-3 hours and pressure sensors to measure how the melt ponds fill and drain. The team also took temperature measurements on the surface of the glacier and used GPS antenna to determine ice flows. This was the first attempt to monitor the effect of surface ponds on the flow of ice in East Antarctica as air temperature around Antarctica warms and thus an increase in melt pond formation could have serious consequences.

Phase sensitive radar deployed on the Amery Ice Shelf had a successful annual maintenance visit, with data retrieved and plans to continue monitoring these with fibre optical temperature strings.

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. These are expected to continue in 2017/18.

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 (Asay-Davis et al 2017).

The first idealised coupled ice-sheet/ocean model experiments of their kind, using a new framework developed in collaboration with Dr Rupert Gladstone at the University of Lapland, Finland, were completed and presented at several key meetings during the reporting period.

Also in a first of their kind, work in the ice mechanics laboratory is involved in a series of ongoing experiments to investigate the temperature dependence of ice flow rates and how ice deforms at temperatures close to the pressure melting point temperature.

A joint ACECRC – Antarctic Gateway Partnership position analysis ‘the Antarctic ice sheet and sea level’ was published, providing a science overview assessing the vulnerability of the Antarctic ice sheet and the need to provide more reliable projections of global mean sea level and its geographical distribution. The publication provides a list of future priorities to quantify the past, present and future Antarctic ice sheet mass budget and its influence on sea level, especially for the East Antarctic ice sheet, which contains the largest mass of ice.

The ACECRC, along with the Antarctic Gateway Partnership and IMAS, successfully hosted the 2017 Asia-Pacific Regional Ocean Modelling System Workshop held on 17-21 October 2016. This workshop, co-funded and supported through successful grants from the US Navy Office of Naval Research - Global and University of Tasmania Research Enhancement Grant Scheme, consisted of 3 days of science lectures from international ocean modellers and 1 day of tutorials and model development discussions, and was attended by nearly 100 international scientists, and strongly promoting Tasmania as a hub of polar ocean modelling. Talks covered topics such as ocean circulation, ice/ocean modelling, data assimilation and general numerical modelling.

The project was successful in securing an in-kind German Space Agency grant for Terra SAR-X synthetic aperture radar imagery of the Sabrina Coast (including Totten Glacier/Ice Shelf and surrounding regions), valued at \$250,000.

The project also had several visitors over the reporting period. Dr Michael Dinniman from Old Dominion University, USA, visited in October 2016 to collaborate with researchers on ice-ocean modelling. Dr Rupert Gladstone from the University of Lapland, Finland visited for two months in January 2017 funded by the UIAS visiting scholars scheme to work with ACECRC researchers and students to further coupled Ice sheet-Ocean modelling efforts. Dr Thomas Zwinger visited for three weeks in March 2017 from CSC- ITCentre for Science Ltd in Helsinki, Finland funded by the UIAS visiting scholars scheme and in conjunction with the Antarctic Gateway Partnership to work with a number of researchers and students using Elmer/Ice modelling software on a number of projects.

Research Project 1.3 Sea Ice Processes and Change

Project Summary

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.

Focussing on the Antarctic marginal ice zone (MIZ) is important because it forms the highly-dynamic outer part of the circumpolar sea-ice zone where the interaction of atmosphere, ocean and ice is particularly intense. Processes occurring there are thought to play a key role in driving seasonal sea-ice advance and retreat, but we lack even fundamental knowledge of the interactions and feedbacks and how

these vary (and change) over space and time. This research direction represents an important step towards understanding observed changes in Antarctic sea-ice extent and seasonality on time-scales from seasons to centuries, and to improve the skill of climate models in more accurately simulating current sea ice conditions. This will in turn give more confidence to model projections of future sea ice change and effects. The Antarctic MIZ is also very important to primary productivity, the krill-based Antarctic marine ecosystem and biogeochemical cycles, and represents an excellent opportunity for multi-disciplinary research across the ACECRC environment, including the Atmosphere group.

Closer to the coast, landfast sea ice (fast ice) and polynyas are two other major elements of the interactive air-ocean-sea ice system that are integral to Antarctica's role in global climate and ocean circulation – one as a narrow yet consolidated interface between the ice-sheet margin and pack ice/ocean, and the other as the site of greatly-enhanced sea-ice production and salt input into the ocean. Both are sensitive to climate change, and are closely related. ACECRC research is focusing on how sea ice processes drive dense shelf-water formation and ocean-ice shelf interactions, as well as detailing the role sea ice plays in ecosystem habitats and carbon cycling.

The work involves remote sensing (analysis of satellite and tagged-seal data) and modelling (high-resolution global ocean/sea ice/ice shelf), and is linked to external multi-disciplinary fieldwork on fast ice involving strong collaboration between the Australian and New Zealand Antarctic programs (AAS/AAD Project 4298 led by ACECRC researchers). The overall objective of the latter project is to expand the measurement capability for, and multi-disciplinary observational record and understanding of, Antarctic fast ice characteristics and processes, to assess the impacts of climate change on physical and biological elements of the coastal sea ice zone. Dr Heil is leading the international Antarctic Fast Ice Network, an ongoing programme aimed at encouraging international cooperation and standardisation in fast-ice measurements around the continent (in concert with automatic weather stations and autonomous instrument packages). Details are at:

<http://seaice.acecrc.org.au/a fin/>

The Sea Ice Physics and Ecosystem Experiment II (SIPEX-II, 2012) yielded rich new information about sea ice and snow cover thickness, morphology and evolution in the inner pack ice zone of East Antarctica. Multi-disciplinary synthesis of data from this and the earlier SIPEX I (2007) voyage, and the upscaling of these data to regional scales, is being out in this project and the work will be extended to the wider East Antarctic domain in associated work towards i) mapping regional-scale sea ice surface roughness and freeboard using existing airborne data, and ii) providing a first estimate of East Antarctic sea-ice volume through melding of satellite, existing in situ and modelling data.

Research Activities 2016/ 17

A centrepiece of the project is a continuation of the 'AUV Under Sea Ice' project, based on extending the floe-scale pack ice work from SIPEX-II across other parts of the sea ice zone. This will build upon the technical and scientific partnership with the Woods Hole Oceanographic Institution (WHOI). ACECRC scientists are joining WHOI-led projects on multiple international sea ice voyages, by co-funding the AUV equipment pool, contributing personnel and UAV capacity through the ARC funding of Dr Guy Williams. By co-funding a second SeaBED-125 vehicle, which is the next

generation of low-cost, sea-ice specific AUVs, ACECRC will decrease risk and achieve enhanced research outcomes through increased operational capabilities.

To date, ACECRC researchers have participated on the ONR-funded Arctic marginal ice zone (MIZ) project termed 'Seastate' in October/November 2015 and the NSF-funded 'PIPERs' voyage to the Ross Sea in April/May 2017. These voyages extend the SIPEX-II AUV work to the Marginal Ice Zone (MIZ), polynyas and inner pack, across key regions of Antarctic sea ice research.

This approach is enabling our participation in world-leading integrated sea ice research voyages and continued access to the state-of-the-art AUV technology. Furthermore, this collaborative work will build our capacity for future Australian-led integrated experiments in the East Antarctic sea ice zone (with some focus on the MIZ).

There has been a strong uptake and use of project data by both national and international cross-disciplinary studies (with co-authorship) e.g., two papers investigating the effect of Antarctic sea ice variability on southern elephant seal foraging behaviour and ecology (Labrousse et al., 2017 x 2). Requests for use of project fast ice and wider sea ice datasets in research by third parties have continued to be fairly frequent e.g., towards biology/ecology studies. The sea ice information is also of considerable importance in support of other work towards milestones across the ACECRC.

A new modelling analysis of causes of the recent record low and high Antarctic sea ice extents resulted in a paper submitted to *Geophysical Research Letters* (Kusahara, K., Reid G. D. Williams, R. Massom and H. Hasumi (2017), 'An ocean-sea ice model study of the unprecedented Antarctic sea ice minimum in 2016', *Geophys. Res. Letters* – in review).

Another paper nearing completion for submission to *Nature* details the contribution of regional sea ice loss to the nature and timing (triggering) of recent ice-shelf disintegration events on the Antarctic Peninsula since 1995, including the effects of fast ice loss on the 2008 and 2009 disintegrations of the Wilkins Ice Shelf (Massom et al). This ground-breaking study is based on synthesis of satellite, wave reanalysis and ice shelf-wave-sea ice interaction model data. Results were presented at the IGS Symposium, Wellington, New Zealand, February 2017.

Analysis of fast-ice samples from November-December 2015 has begun after the stranded science samples, sea-ice refer lab MGS002 and science container MSG026 returned from Davis Station on V1 2016/17.

ASPECT bridge-based observations have been undertaken on every continental Antarctic voyage in 2015/16 and 2016/17, plus completion of ice-radar acquisitions for 2016/17.

An ARC Discovery Grant was awarded to Guy Williams 'Advancing Wave-Ice Models of the Marginal Ice Zone with Autonomous Platforms', together with co-PIs from NIWA (Dr Alison Kohout), WHOI (Ted Maksym) and Northern University (Hanuman Singh). The grant (\$254,000) will provide the necessary sensors for the ACECRC Seabed-125 AUV (\$US110K co-investment by the ACECRC) and provide \$50K to NIWA to support the wave-ice buoy project.

Drs Phil Reid and Rob Massom are co-investigators on a newly-funded multidisciplinary project led by Dr Katie Leonard, within the Swiss Antarctic Circumpolar Expedition project. This study will measure snowfall and sea-surface salinity (and temperature) around Antarctica, and will potentially cast light on whether the extent to which ocean surface freshening may be contributing to observed change in sea-ice coverage.

A philanthropic grant received by the ACECRC has enabled Dr Simon Alexander to place an Ocean Rain distrometer on the *MS The World*. The instrument measures the size and number of precipitating water droplets and ice particles. The first cruise to the Ross Ice Shelf occurred in Jan-Feb 2017, and the measurement suite included AAD radiometers and all-sky cameras. The data will be used to assess fresh water flux into the Southern Ocean for investigation of sea ice processes and evaluation of climate model simulations and satellite measurements.

ACECRC scientists (Drs Rob Massom and Will Hobbs) made a significant contribution to a new US National Academy of Sciences report on “Antarctic Sea Ice Variability in the Southern Climate-Ocean System” (Washington, DC: The National Academies Press, doi:10.17226/24696, 2017).

Continued leadership of the annual analysis of Antarctic sea ice extent, concentration and duration for the annual NOAA/BAMS State of the Climate Report that is, inclusion of new results in the reports for 2015 (Reid et al., 2016) and 2016 (Reid et al., in press). These annual reports effectively entail “interim IPCC Assessment reports”, and are therefore of considerable importance for informing policy makers regarding the current state of Antarctic sea ice.

Key work is underway toward merging the sea ice-ocean-ice shelf model to the atmosphere component of ACCESS 1.0, in order to develop a fully coupled climate model for assessing circumpolar sea ice behaviour. This is being conducted by Dr Kusuhara and Dr Marsland, CSIRO.

Fast ice mapping time series extended (Alex Fraser) – 2000 to present (and ongoing) at 1 km resolution in focus regions (Adélie/George V Land Coast, Mawson Coast, Prydz Bay, Ross Sea), in support of biology/ecology studies etc.

The project had several visitors over the reporting period. A/Prof Jennifer Hutchings from Oregon State University, USA, visited in September 2016 to work on ASPECT/Assist unification and revisited in January 2017. Dr Mikko Lensu from FMI, Finland, visited in September-October 2016 to install an ice-radar server on the *RSV Aurora Australis*. Dr Fabien Roquet from MISU, Sweden, visited in November-December 2016 to continue collaborative work with Dr Guy Williams on the use of instrumented elephant seal data for assessing polynya activity in East Antarctica. Prof Vincent Favier from the University of Grenoble Alpes, France, visited in January 2017 to discuss the Antarctic traverse (R1.4) and AWS network.

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

Project Summary

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.

Detailed records of past climate improve understanding of global, hemispheric and regional climate dynamics, including responses to natural and anthropogenic forcings. Such records also provide improved understanding of natural climate variability on decadal to centennial time scales, and of changes over the anthropogenic era. Ice cores give climate records that mesh with the relatively short instrumental records from Antarctica and high southern latitudes, which enable global reconstructions and allow the role of Antarctica on climate to be better understood. Ice cores are a unique source of past climate information as they record proxies for both climate responses, and the major forcings (greenhouse gases, solar variability and volcanic aerosols). This project is fully aligned with major international ice core and palaeoclimate initiatives, and is producing a range of climate parameters through national and international collaboration.

Temperature and climate forcings: This project will produce a high resolution 2,000 year climate record, the first from an inland East Antarctic site. The 2,000 year record will include information on snow accumulation rate, atmospheric temperatures (from water isotopes), greenhouse gas (GHG) forcing (from highly resolved CO₂), volcanic forcing (from sulphate), solar forcing (from 10 Be) and climate variability (SAM/ENSO). The Aurora Basin (ABN) record will allow a high resolution assessment of the influence of natural solar and volcanic forcings on our climate, and the recent anthropogenic influence of GHG forcing. This assessment is of critical importance to the climate modelling community, and will significantly enhance efforts to understand the dynamics of the climate system over this 2,000 year period, including carbon cycle-climate feedbacks, sea ice feedbacks, and atmospheric dynamics feedbacks. The temperature record will also be used to constrain and evaluate the models used to project future climate change. Also, records of CO₂ and its isotopes will improve our understanding of the hemisphere gradient of CO₂ and gain a better understanding of the carbon cycle.

Snow accumulation rate: Links between rainfall in South West Western Australia and snowfall at Law Dome have been found from our work on the coast (van Ommen and Morgan, 2010), and these links will be further investigated using the ABN accumulation series extending back 2,000 years. The precipitation regime at Law Dome differs significantly from the inland sites, the former being dominated by cyclonic systems, while inland is dominated by clear-sky 'diamond dust' precipitation (e.g. Masson-DeMotte et al., 2000). Probing the transition between the two types of record in conjunction with high resolution data sets should provide for much better extraction of a common climate signal. At present, it is not well understood if proxy calibration based largely on clear-sky precipitation records can be applied to cyclonic precipitation; calibration slopes for water isotopes differ considerably at Law Dome from those in the interior (van Ommen and Morgan, 1997; McMorrow et al., 2004). The high resolution continuous flow analysis proposed for this core will yield annual resolution at this site. High-resolution records of snow

accumulation are required by the modelling community to constrain and evaluate climate system models.

Atmospheric variability: Ice core proxy fingerprints of large scale modes of variability such as the Southern Annular Mode (SAM), El Niño Southern Oscillation (ENSO) and the Interdecadal Pacific Oscillation (IPO), are being derived and compared with meteorological model and reanalysis data for validation. Long term records provide an understanding of natural variability against which climate change detection and attribution can be assessed, as well as providing a valuable record for the evaluation of climate system models. The high resolution ABN record will be compared to the coastal Law Dome ice core record which has sensitivity to the SAM (Goodwin et al., 2004), ENSO (Vance et al., 2012) and IPO (Vance et al., 2015). This 2,000 year record can also be used to assess decadal-to-centennial scale variability. This research will provide high resolution time-series of raw observables to at least 2000 years, interpreted in terms of variability in large scale atmospheric dynamics: westerly winds, SAM, ENSO, and IPO. Additionally, application of these proxies to reconstruct water catchment variability in Australia through hydrological modelling is being investigated.

Sea ice proxies (MSA and sea salts): Assessing changes in sea ice extent (over the longer perspective) is particularly important to understanding current trends. The Law Dome Methane sulphonic Acid (MSA) record has been used as a proxy of sea ice extent in the 80-140°E sector (Curran et al., 2003) as evidence of 20% decline over the last 50 years. Recent data from shallow cores around Antarctica support the use of MSA data as a sea ice extent proxy (Foster et al., 2006; Abram et al. 2007). Data from the more inland Mt Brown site suggests that an inland site (such as ABN), combined with a regional synthesis may provide a more circum-Antarctic sea ice history. The MSA data from ABN will be tested as a proxy and calibrated against satellite data to produce a 2000 year larger scale sea ice history. This work will directly contribute to the new IGBP-PAGES working group on sea ice proxies from ice cores. Our work suggests that frost flowers contribute significantly to the sea salt budget near the source (coast), however, this influence becomes considerably reduced inland at higher altitudes (Curran et al., 2011). A seasonally resolved record at ABN will allow the signature of such encrustations in winter to be investigated for the first time at an inland site, and will contribute significantly to the frost flower debate through comparisons with records from EPICA Dome C and Law Dome. This will provide valuable information to the debate on the strength of competing sources and the interpretation of sea salt levels in ice cores, and whether sea salts can be used to reconstruct sea ice history.

Investigate sources and transport pathways: Dust and aerosol pollutant inputs to Antarctica are powerful tracers of atmospheric circulation. Considerable debate exists regarding the interpretation of dust records. Some investigators use non-sea salt (nss) Calcium as a proxy for dust (e.g. Rothlisberger et al., 2002), however the proportion of nss-Ca is low, producing often noisy, difficult to interpret, records (e.g. Curran et al., 1998). A more direct measure of terrestrial dust is the use of aluminium, iron or rare earth elements such as Cerium (e.g. McConnell et al., 2007), and also the use of particle counts and distributions (e.g. Delmonte et al., 2004). However a multi-tracer approach using a combination of all techniques will be used here for ABN, including a high resolution ice melter with continuous flow analysis to a dual trace element analyser (McConnell et al., 2007). This will be used to produce dust records, fire history, information on trace aerosol sources and atmospheric circulation

strength. This information from ABN, combined with existing Law Dome records will be used to improve a regional synthesis of climate records from East Antarctica. Although Patagonia is thought to be the dominant source of dust found in Antarctica (e.g. Rothlisberger et al., 2002; Delmonte et al., 2004, McConnell et al., 2007), Australian dust sources may be important for East Antarctica (e.g. Revel-Rolland et al., 2006). Our multi-tracer approach for ABN may shed some light on the origin of dust in East Antarctica, and influence interpretations of EPICA Dome C and Law Dome dust records, improving an understanding of sources and transport effects.

Very little is known about the past atmospheric variability of carbon monoxide, a trace gas being the main reagent with the hydroxyl radical in the troposphere, and thus key for atmospheric chemistry. In natural conditions, its main sources in the Southern hemisphere are the oxidation of methane, oxidation of non-methane hydrocarbons and biomass burning. Available ice core records of CO changes cover the last few hundred years (Haan et al., GRL 1996 ; Haan and Raynaud, Tellus 1998 ; Wang et al., Science 2010). The co-investigation of the carbon and oxygen isotopic composition of CO show that most of the observed centennial variability of atmospheric CO can be attributed to biomass burning changes, which may have varied by as much as 40% in the Southern hemisphere between the Medieval Warm episode and the Little Ice Age (Wang et al., Science 2010). A CO record from the Aurora Basin would extend this CO history back in time. Its added-value compared with other ice cores would be to enlarge the range of chemical composition of the ice surrounding the CO samples. This will be critical to investigate small but maybe significant artefacts in the ice, which may affect the CO record in Antarctic ice. Such artefacts are known to take place in Greenland ice (Haan and Raynaud, Tellus 1998). The expected output is a reference record of carbon monoxide changes over the last 2000 years. It would be interpreted as reflecting mostly past biomass burning changes in the Southern hemisphere and in particular in Australia.

Ice core records allow climate observations from instruments to be put in a long term context and to reveal climate connections between Australia and Antarctica. Working closely with international partners, a circum-polar assessment will be made using climate history records from both archived and newly collected data.

Research Activities 2016/17

New work looking at deglacial and Holocene changes in sea salt species is improving our understanding of mechanisms (including sea ice) of change through this period. Dr Jason Roberts has submitted a Law Dome age scale paper which shows this new work and Dr Chris Plummer is working on the Holocene variability seen in the Law Dome record and understanding what the annual sea salt signal represents and relationship with sea ice. Our collaborator, Dr Joel Pedro in Denmark is working on the deglacial changes and relationship with the temperature gradient between the coast and inland Antarctica.

A successful field expedition to Law Dome saw a complete 30m ice core and snow pit. The field party consisted of Dr Mark Curran (AAD/ACE CRC), Dr Jason Roberts (AAD/ACE CRC), Dr Adam Tveinow (ACE CRC), Dr Andrew Smith (ANSTO), and Ms Chelsea Long (UTAS). This project resulted bringing the Law Dome climate record up to 2017 and showed high resolution 10Be and chemical records for comparison. The project also functioned as drill training and testing for the Mount Brown ice-core drilling project.

A study published in the prestigious journal Nature, led by A/Prof Nerilie Abram from the Australian National University and co-authored by AAD and ACECRC glaciologist Dr Mark Curran, showed human-induced global warming began about 180 years ago, much earlier than previously thought, using climate data from ice cores, corals, sediment layers and tree rings. The research found that warming in parts of the Southern Hemisphere was delayed up to 50 years, and that the Antarctic continent is yet to show significant overall warming. The study does show significant regional warming in West Antarctica and the Antarctic Peninsula since the mid-20th century, with warming in these areas among the most rapid seen anywhere on the globe. The study was undertaken by a team of 25 scientists as part of the Past Global Changes (PAGES) 2k Consortium, from Australia (including the ACECRC), the United States, Europe and Asia.

A successful proposal to conduct ice coring at Mt Brown in the 2017/18 summer led by Dr Tessa Vance will see a new ice core from East Antarctica spanning the last 1,000 – 2,000 years of climate history. Preparations are well underway for this fieldwork. Dr Jason Roberts had a successful field season in Greenland (June 2017) drilling ice cores and gaining valuable Danish drill experience in preparation for Mt Brown.

Dr Brett Paul was successful in the last AAS round for his capillary ion chromatography project looking at ultra-low volume/ultra-high resolution ice-core analysis. This will facilitate increasing resolution we can extract out of ice cores and improve studies such as the Vance rainfall reconstruction work.

Engagement with Dr Anthony Kiem from the University of Newcastle regarding hydrology work continued during the reporting period. In addition to this collaboration, \$150K from the Queensland government was granted to Drs Anthony Kiem and Tessa Vance for SEQ drought reconstruction work.

Dr Chris Plummer commenced a technical position within the ice core team to establish an ice core melter and as Mt Brown technical assistant. This will establish a continuous flow melter system which can produce continuous isotope and chemical samples for much quicker analysis than traditional methods.

Research Project 2.1 Carbon Uptake and Chemical Change

Project Summary

Research Project 2.1 is determining whether the Southern Ocean will continue to moderate climate change via uptake of atmospheric CO₂, quantify regional and seasonal variations in the extent of ocean acidification, and examining iron supply as the limiting nutrient underpinning Southern Ocean productivity. The project will assess the evolving Southern Ocean carbon dioxide and oxygen uptake, acidification, and iron supply. It will determine the interplay of natural and anthropogenic factors that mediate regional and temporal variability in the changes, as a base for understanding biological responses. The work will contribute to the efforts of the international research community and others on the links between climate change, ocean circulation, biogeochemistry, and primary productivity.

The ocean absorbs CO₂ from the atmosphere, slowing the rate of climate change on land. The Southern Ocean takes up more atmospheric CO₂ than any other latitude band. This uptake will not continue at current rates if ocean warming

reduces the rate at which the surface ocean can absorb atmospheric CO₂, if decreasing overturning circulation reduces its transfer to the deep ocean, or if biological changes reduce the transformation of CO₂ into organic matter. The pathways of CO₂ uptake are complex, involving that lower limb of the meridional overturning circulation that is influenced by ocean interactions with the cryosphere (modulating the formation of Antarctic Bottom Water) and the upper limb that involves processes in the Subantarctic Zone, including interactions with changing boundary currents such as the East Australian Current. These pathways are further modulated by biological processes that transform CO₂ into organic matter (via photosynthesis) and allow this carbon to reach the deep sea in sinking particles rather than via the circulation. None of these pathways are well quantified, and their relative importance varies with the time scales of interest. The upper limb is dominant on the decadal scale, the lower limb on centennial to millennial scales, and the biological pump on longer time scales. Sustained observations of interannual and interdecadal variations in modern uptake, complemented by process studies for projection of future changes and the testing of these projections against past variations, are required to improve this situation. Improvement of this situation is a key focus for Project 2.1 especially via the Southern Ocean Time Series and SR3 signature projects and the new carbon postdoctoral appointment.

The Southern Ocean and Antarctic host iconic ecosystems of high conservation value, including deep ocean communities that are only now being discovered. These ecosystems are at risk from global changes including physical changes such as loss of sea ice habitat and ocean warming, and chemical changes such as ocean acidification from CO₂ uptake, and changes in the supply of the trace metal iron, which limits phytoplankton growth in the Southern Ocean. This trace element control also affects phytoplankton species composition and physiology and the cycling of other nutrient elements, and thus the structure of the entire marine ecosystem. Production also affects the impacts of ocean acidification, because phytoplankton growth removes CO₂ and thus counters the anthropogenic acidification.

Changing iron supply is the least understood forcing on ocean ecosystems. Since iron is actively taken up into phytoplankton, and transferred throughout the food web, including removal by particle settling and remineralisation in deep waters, the assessment of its availability is quite complex and cannot be judged from dissolved iron levels in surface waters alone. Recent international advances in chemical oceanographic techniques for trace elements now allow the measurement of iron associated with different phases (dissolved and particulate), internal biological recycling and iron export from surface waters. The dominant new iron fluxes may be associated with the particulate phase, and particles thus represent an important transport vector for trace metals in the marine ecosystem, although their bioavailability or transfer into a bioavailable fraction remains uncertain. Surveys of iron distributions and process studies of iron transformations are needed to advance understanding of the potential for significant changes in primary production, and thus impacts on food webs and carbon cycling. Improvement of this situation is a key focus for Project 2.1, especially via the SR3, Southern Ocean Time Series (SOTS) moorings, and Kerguelen region field projects, and the two new postdoctoral trace element appointments.

Research Activities 2016/17

Assessing ocean change requires sustained commitment, and this year exemplified that effort by carrying out work on the two longest running ACECRC signature projects: the SR3 repeat hydrographic section from Tasmania to Antarctica and the Southern Ocean Time Series.

The SR3 repeat section, led by Research Project 1.1, has been a mainstay of Australian contributions to global efforts to understand the role of the ocean in climate change, with sequential sponsorship by WOCE, CLIVAR, and now GO-SHIP. The southern end of the SR3 repeat section of the Southern Ocean between Hobart and Antarctica was successfully completed in 2016/17 aboard the *RV Aurora Australis* on voyage V2. The use of the icebreaker allowed expanded work on the biogeochemistry of ocean-cryosphere interactions, with carbon system measurements on the southern end of the section and near the Mertz, Totten and Ninnis glaciers (led by Dr Bronie Tilbrook), and carbon system and iron sampling in sea ice and seawater (led by Dr Delphine Lannuzel in collaboration with VIMS and ECU). Mean CO₂ flux was an order of magnitude higher in the Mertz/Ninnis than in the Dalton polynya. High subsurface particulate organic carbon levels in all three polynyas suggests high organic carbon export late in the summer season. Extremely high particulate Fe at the base of the sea-ice in front of the Totten glacier may derive from ice shelf melt waters. Onboard experiments found that iron and carbon leached from melting sea ice did not stimulate biological activity. Instead, light or grazing pressure may exert limitation on algal biomass in this area, at this time of year. Further evaluation is underway via comparison to V2 photosynthetic parameters, algal taxonomy and krill abundances. Interpretation of these and other field results, and planning for future studies, is supported by implementation of the LIM-1D sea ice biogeochemical model (in collaboration with Dr Martin Vancoppenolle from L'OCEAN, France).

The remainder of the SR3 transect will be completed in 2017/18 on the *RV Investigator*, with the carbon system work to include additional tracers of air-sea exchange (radiocarbon measurements in collaboration with WHOI and Princeton) and new instrumentation to measure ¹³CO₂. The team will also be providing calibration data for pH sensors on biogeochemically equipped profiling floats for the Princeton led SOCCOM project, and will be collaborating on deployment and calibration of new surface pCO₂ drifters developed by JAMSTEC (Japan). The biogeochemistry work will expand to carry out a full GEO TRACES suite of observations of more than 20 trace elements and their isotopes in the dissolved and particulate forms, including iron which is the primary driver of Southern Ocean primary production, and radiogenic isotopes which inform paleoclimate reconstructions. The biogeochemistry component will be led by Dr Andrew Bowie, who was recently elected as co-chair of its international Scientific Steering Committee).

In addition to this SR3 field work, new efforts were made to extract value from the long term SR3 time series. Reanalysis of the carbon system from the past 20 years of SR3 repeats was carried out, including partitioning changes across water masses and separating them into those caused by changes in circulation versus uptake of anthropogenic CO₂. This comprehensive work (led by Dr Paula Conde-Pardo, in press in the Biogeosciences "Oceans in a High CO₂ World IV" special volume) suggests that increased upwelling in Antarctic waters, driven by increased westerly winds, releases old CO₂ to the atmosphere, but that this is more than offset by

uptake in subantarctic waters. This provides deeper understanding of the causes of changes in air-sea CO₂ exchange observed using the global compilation of surface pCO₂ values obtained from underway measurements. The latest version of this effort, SOCAT version 5, was released in June 2017 (www.socat.info), with 21.5 million uniformly quality-controlled, surface ocean fCO₂ fugacity of carbon dioxide observations from 1957 to January 2017 for the global oceans and coastal seas. The Tilbrook carbon team led the Southern Ocean component of SOCAT and are major contributors of data for the region. Previous SR3 results also contributed to the understanding of the role of iron as a limiting micro-nutrient for ocean productivity, which was synthesised in an article describing the diverse sources of iron and its cycling processes and intricate linkages with the ocean carbon and nitrogen pumps (led by UIAS-ACE visiting scholar Dr Alessandro Tagliabue with Dr Andrew Bowie and Dr Philip Boyd (R2.2) as co-authors and published in the prestigious journal *Nature* in February 2017).

The Southern Ocean Time Series (SOTS) annual redeployment of an automated suite of moorings was successfully completed on *RV Investigator* voyage INV2017_02. This year saw expanded work on trace element cycling with deployment of an automated sampler on the SOFS-6 mooring designed to obtain a first ever high resolution seasonal cycle of iron availability (led by Dr Pier Van der Merwe), and examination of remineralisation processes in the mesopelagic zone, which control the retention versus loss of iron from surface waters (via collaboration with the ACE R2.2/IMAS-AGP/ANU team). This work will further the delivery to the 2017/18 R2.1 milestone to build "new perspectives built on carbon cycling by synthesising high frequency automated observations using the Southern Ocean Time Series (SOTS)", which is already well advanced with papers on CO₂ cycling and ocean productivity published previously (Weeding and Trull, 2014; Shadwick et al., 2015) and new work this year showed that a diverse phytoplankton community contributes to carbon uptake throughout the summer, even after silicon depletion affects diatom communities (worked by Dr Ruth Erikson, in press in *Marine Ecology Progress Series*). Strong collaboration with the Australian Gateway Project (AGP) also led to an assessment of the role of eddies transiting the subantarctic front in the uptake of CO₂ in the subantarctic zone (led by AGP's Dr Sebastien Moreau and published in *Global Biogeochemical Cycles*).

There was also good progress on sample and data analysis from last season's major field programs K-axis (the Kerguelen Axis biogeographic survey led by R2.3) and HEOBI (Heard Earth Ocean Biosphere Interactions). Results were synthesised at project workshops in IMAS Hobart (HEOBI) in November 2016 and AAD Kingston (K-axis) in February 2017, and papers will be presented at the Symposium on Kerguelen Plateau Marine Ecosystem and Fisheries at CCAMLR Hobart in November 2017. Peer-reviewed articles are on track to follow in a special issue of *Deep-Sea Research II*. This work will address milestone R2.1.1 'Iron inputs and carbon cycling responses downstream of the Kerguelen-Heard Islands examined'.

An Australia-wide aerosol sampling program (led by Dr Andrew Bowie) assessing the role of the atmosphere in delivering trace metals and nutrients to the ocean, which consists of both time-series at land based sites and large-scale surveys on-board voyages of *RV Investigator*, was expanded in 2016/17. The ACE CRC supports the Southern Ocean sector of this program, and this will include additional observations of atmospheric deposition along SR3 and SOTS in the coming year.

Dr Cathryn Wynn-Edwards joined the program as a marine analytical chemist responsible for the SOTS sediment trap program sample processing and analysis. She is advancing the processing of the back-log of information that has accumulated since departure of the previous marine analytical chemist in 2015.

Dr Christina Schellenberg, who had previously joined the team to participate in the K-axis program, extended her involvement by winning a Canadian postdoctoral fellowship (which will be co-funded by the ACECRC for 2 years), to look at bio-optical indices of phytoplankton physiological status, especially stress induced by lack of iron. She also completed a 3 month contract with us to implement quality control of SOTS fluorescence and backscatter sensor data (funded by IMOS), leading to a published QC manual and delivery of quality controlled data for the period 2008-2016 to IMOS and AODN.

Dr Andrew Lenton (CSIRO) joined the team and immediately made important impacts with publications on the pathways of anthropogenic CO₂ uptake into the ocean interior, the progress and plausible future of ocean acidification in Australian waters, and the likelihood that efforts to remove CO₂ from the atmosphere will be countermanded by return of anthropogenic CO₂ from the ocean.

Dr Bronie Tilbrook attended a GEOSS Asia-Pacific partnership workshop in Japan (January 2017) to discuss ocean acidification and consider GEOSS alignment with GOA-ON for the June 2017 meeting in New York on UNDP Sustainable Development Goals for the Oceans, including 14.3 on Ocean Acidity. Bronie serves as co-chair of the Global Ocean Acidification Observing Network (GOA-ON), contributed to the UN Oceans meeting on Sustainable Development Goal on ocean acidity (June 2017), and is working with IOC/UNESCO and the International Atomic Energy Agency to further develop the observing network, including in the Southern Ocean. The Global Ocean Acidification Observing Network created a data portal for ocean acidification that became online in August 2016 and will include Southern Ocean data from the ACECRC (<http://goa-on.org>).

Dr Andrew Bowie was elected as co-chair of the Scientific Steering Committee of the international GEOTRACES program. He has formerly served as co-chair of the Data Management Committee and was fundamental to the construction and delivery of the second GEOTRACES Intermediate Data Product released in August 2017. ACECRC researchers have played a lead role in the provision of Australian data to the Data Product following earlier ocean sections in the Pacific, Indian and Southern Oceans.

Dr Tom Trull participated in the Aus-India Strategic Research Fund Robotic Ocean Observations workshop in Perth in December 2016 to advance the development of Indian Ocean observing networks. One outcome was synthesis of data (led by CSIRO's Dr Bozena Wojtasiewicz and in review in Journal of Marine Systems) from 10 profiling floats deployed in the Arabian Sea by Indian national agencies NIO and INCOIS. This work documents the distribution of denitrifying microbial communities (estimated from optical backscatter) in hypoxic waters (estimated from optode sensors) and suggests that it is limited to more oxygen depleted waters than expected, perhaps because grazing pressure can remove these microbes everywhere except in the very core of the low oxygen "dead zones". This work shows the power of this autonomous technology and helps to develop the case for an expanded Australian Biogeochemical Argo program for consideration of future funding by IMOS and potentially the ACECRC renewal bid. Dr Trull also accepted a position as Distinguished Visiting Scientist at the State Key Laboratory for the Marine

Environment at Xiamen University, China and took leave without pay to be in residence there in July-August 2017, to work on optimization of spectrometric nutrient sensors, and their application to assessment of coastal eutrophication.

R2.1 welcomed several new PhD students. Luis Duprat started an AGP funded PhD in August 2016 on the bio-availability of iron in the sea ice environment with ACECRC supervisors Drs Delphine Lannuzel and Klaus Meiners. Cristina Genovese started an AGP funded PhD in December 2016 on the role of organic ligands on the Fe cycle in polar waters with ACECRC supervisors Drs Delphine Lannuzel and Kathrin Wuttig, and participated in the Aurora Australis V2 to collect samples for her and Luis's PhD projects. French co-tutelle PhD student Manon Tonnard returned to ACE in 2017 to complete her PhD studying the iron organic complexation around the Heard-Kerguelen archipelago, with ACECRC supervisors Dr Andrew Bowie and Dr Pier van der Merwe.

Research Project 2.2 Biological Responses to Environmental Change

Project Summary

Research Project 2.2 is investigating how key Southern Ocean biota respond to multiple physical and chemical changes, such as warming and acidification.

Climate change and ocean acidification are considered to be major threats to Southern Ocean ecosystem structure and function. Potential impacts identified in the Fifth Assessment Report published by the Intergovernmental Panel on Climate Change in 2014 include poleward shifts in geographical distributions, population collapses or local extinctions, failure of large-scale animal migrations, changes in the seasonal timing of biological events, and changes in food availability and food web structure.

Microbes at the base of the food web control the flow of energy into food webs and the biological pump (through phytoplankton primary production), and mediate the recycling of key plant nutrients such as nitrate and iron (through heterotrophic bacteria). Studies at high latitudes have already identified that the community composition of the species and groups that comprise the base of the food web are likely to be altered by changing oceanic and sea ice conditions. Changing conditions may also directly influence higher levels in the food web, which can create not just bottom up, but also top-down pressures. The potential for many consequential pressures may alter the predator-prey relationships, which may in turn cause changes in the relative importance of different energy pathways. At present, energy transfer to higher trophic levels is primarily through Antarctic krill (*Euphausia superba*). Change may give rise to a copepod-fish pathway becoming more important in some areas.

Sea ice is a major driver of Southern Ocean food webs. From studies in the West Antarctic Peninsula region, recruitment and abundance of krill is hypothesised to be dependent on the extent of winter sea ice. The mechanisms proposed for this relationship hinge on the reliance of krill (particularly krill larvae) on the microbial communities that grow on the underside of sea ice. Krill feed on these communities during times when food in the water column is scarce. Whether this relationship holds true for the different sectors around Antarctica remains unclear. Understanding regional differences in the dependency of pelagic food webs on sea ice conditions

is critical for a proper assessment of the impacts of changing sea ice conditions on Antarctic marine ecosystems.

Experimental studies in controlled environments of the physiology of keystone species or groups, particularly at lower trophic levels (bacteria, phytoplankton, zooplankton and Antarctic krill) will enable an assessment of the response of species – to both individual and multiple environmental stressors – to changing environmental conditions are more likely to occur. These studies will also be used to characterise their life history and population dynamics in models which will be used to predict the fate of phytoplankton, zooplankton and krill in the Southern Ocean under various IPCC scenarios and fishing regimes.

Research Activities 2016/17

Further research into how Southern Ocean ecosystems are responding to the impacts of climate change was conducted in both shipboard and lab-based experiments. Dr Ruth Erikson, Dr Kohei Matsuno and Ms Christine Weldrick (PI- Dr Kerrie Swadling) participated in the Umitsuka-maru voyage along the 110E meridian in January 2017. This is an on-going collaboration between Japan and Australia to study Southern Ocean ecosystems. On this voyage, the Australian participants carried out successful collection of samples, ran ocean acidification experiments on pteropods (calcifying zooplankton), and a suite of live zooplankton were captured for further experimentation back in lab-based studies in Hobart. Mr Satoshi Nirazuka (postgraduate student of TUMSAT) worked with Dr Kerrie Swadling and Dr So Kawaguchi on fish larvae samples from the Umitsuka-maru cruise between January and August 2017.

Ocean acidification experiments on krill and the collection of live krill took place on the Aurora Australia V2 (2016/17, PIs Dr Swadling and Dr Kawaguchi) and were very successful. Also on this voyage, the vessel's acoustic echo-sounder was calibrated in cold-water. This calibration is important for processing krill and fish acoustics from 2015 and 2016 voyages, including K-Axis. The 200 KHz sonar was unable to be calibrated on the voyage, and was theoretically calibrated. A series of environmental manipulation experiments on mesozooplankton were also conducted during a successful summer season at Dumont d'Urville (PI- Dr Swadling) in East Antarctica.

In lab-based environmental manipulation experiments at IMAS under simulated polar and subpolar conditions, Dr Kristen Karsh (PI- Dr Philip Boyd) conducted a further suite of studies on the joint effects of temperature and trace metal supply on phytoplankton. These experiments built on prior work from January to April 2016 with US visiting scientists from USC, Los Angeles, and they pinpointed for the first time tipping points above which there was a pronounced decline in phytoplankton growth rates. Analysis of the samples and assays from a major (that is, a whole community from microbes to crustacean zooplankton) subantarctic multi-stressor (warming; acidification; nutrient supply; irradiance; iron supply) factorial matrix experiment continued. Analysis ranged from chemical through to molecular biological assays, which are currently being prepared as a manuscript for submission to an international peer-reviewed journal. Findings from Dr Kristen Karsh's and Dr Marion Fourqurean's manipulation studies with polar phytoplankton and microbes were presented at the ACECRC 2016 Symposium.

Dr Philip Boyd synthesised the findings – from microbes to krill – for both lab and field studies and presented them (“ACE project R2.2 Biological Responses to Environment Change: A primer”) to the Research Users forum at the Shine Dome, Canberra, 6 April 2017. There was considerable interest from research users in the new data on phytoplankton environmental tipping points in a warmer Southern Ocean. Dr Sinead Collins (an experimental evolutionary biologist at the University of Edinburgh) worked with Dr Boyd and Dr Karsh in March and April 2017 on the evolutionary implications of the thermal tipping points that were evident for Southern Ocean phytoplankton.

Professors Philippe Koubbi and Jean-Baptiste Favier (Université Pierre et Marie Curie, Paris) worked with Dr Kerrie Swadling on the irlong-term project examining sea ice, zooplankton and fish at Dumont d’Urville in East Antarctica. Dr Philip Boyd is continuing his collaboration with Dr Elena Litchman from the University of Michigan on the differential susceptibility of organisms across multiple trophic levels to complex ocean change, and they recently submitted a manuscript to an international peer-reviewed journal.

Dr Philip Boyd chaired two conferences in July 2016; the 2nd Gordon Research Conference on Ocean Global Change Biology in New Hampshire; and the SCOR WG 149 on Changing Ocean Biological Systems in the US. Dr Boyd was awarded 20K Euro to convene a workshop (June 2017) to develop a Best Practice Guide to designing experiments on multiple oceanic drivers on marine biota by the IAEA. Dr Kerrie Swadling and PhD student Christine Weldrick were awarded grants from ANSTO and the Holsworth Foundation to undertake an analysis of stable isotopes of Southern Ocean pteropods. Dr Klaus Meiners was awarded the Hanse-Wissenschafts-Kolleg (HWK) - European Institute of Advanced Studies fellowship to work at AWI late 2017.

Dr Eun Jin Yang (Korean Polar Research Institute) is visiting Dr Klaus Meiners from April 2017 until March 2018 to work on sea-ice algae and environmental drivers.

Research Project 2.3 Status and Trends in Ecosystems

Project Summary

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.

Marine ecosystems provide a broad and important range of services to people and the environment, from food security to sewage disposal. They are also significant in the global carbon cycle, playing an important role in sequestering carbon from the atmosphere. These ecosystems are changing and will continue to change over at least the next 100 years as the ozone layer recovers and as climate change and ocean acidification continue to modify ocean habitats. Governments and administrators aiming to minimise impacts on ecosystem services need policy and regulatory frameworks that can respond in a timely manner and without causing rapid upheavals in how marine ecosystems are used and conserved. For example, how to manage the rapidly expanding krill fishery within a changing ecosystem, including changes as a result of the recovery of whale and seal populations from past exploitation.

Climate change poses greater difficulties for policy makers and managers than the usual forms of environmental management because the effects of actions are not seen immediately; increased concentration of greenhouse gases will likely result in changes to ecosystems only after many decades, as demonstrated by the 50-year time frame expected for the recovery of the ozone hole after cessation of emissions of ozone-depleting substances.

In order to ensure ecosystem services are sustained in the face of future change, the following capabilities are required:

- robust early-warning indicators of change;
- robust assessments of the likelihood of different future states of ecosystem services given different management options or scenarios; and
- mechanisms for adjusting management options to take account of new information.

The recent Fifth Assessment Review of the Intergovernmental Panel on Climate Change describes how these capabilities are essential for the Southern Ocean but are currently poorly developed. Initiatives in SCAR, SCOR and IMBER provide important forums for coordinating and achieving these capabilities by 2020. This project will play an integral and leading role in these initiatives, particularly in delivering these capabilities for the Indian Sector of the Southern Ocean.

The project has a quantitative framework to undertake ecosystem assessments, with a preliminary assessment made in the first year, and will use existing models, data sets and scenarios of future environmental change. It is identifying key gaps and uncertainties to guide priorities for both this project and Research Project 2.2. Existing models and data are being used to design a cost-effective field program to obtain new data required to resolve uncertainties in status and trends and to improve model performance. This project is combining work across the ACECRC and international programs to deliver up-to-date, quantitative assessments for use by the Australian Government, IPCC, CCAMLR, IWC and other bodies as a basis for management in the region.

Research Activities 2016/17

A framework for assessing dynamics and change of Southern Ocean ecosystems has progressed with publication of statistical models and predictions for algae and krill in sea ice habitats (Melbourne-Thomas et al 2016, Meiners et al 2017) and a comprehensive assessment of change in habitats in general is nearing publication.

Sample processing for the Kerguelen Axis marine science voyage (2016) is nearing completion and manuscripts are in progress (to be published in a special issue in Deep Sea Research II).

Good progress has also been made on the development and implementation of an ensemble of ecosystem models for evaluating the likelihood of future ecosystem states in the Indian Sector of the Southern Ocean. The East Antarctic Atlantis model is running and is undergoing calibration. Other components of the model ensemble that have been developed or are currently under development include: size-based models for the Kerguelen Plateau, an implementation of the French SEAPODYM model (a stage-based model for fish-based ecosystems) for the Indian Sector, particle tracking models and mass balance foodweb models. The ACECRC has a

significant role in the European Union Mesopelagic Southern Ocean Predators and Prey (MESOPP) Project, which is fusing acoustic data with ecosystem modelling and assessments of predator foraging areas. It is primarily aimed at building cooperation between EU and Australia with the intention of leading to a bigger project in the future. The work of MESOPP has been agreed to be of great importance to CCAMLR by CCAMLR's Working Group on Ecosystem Monitoring and Management (WG-EMM).

The consultation draft of the new position analysis "Managing Change in Southern Ocean Ecosystems" was presented to end-users at a Research User forum held in Canberra on 6th April 2017. This position analysis updates the Australian Government and the community on the latest developments in research into the impacts on climate change on Southern Ocean ecosystems, explains the techniques that are being used, those that are being developed, and the future development of tools capable of reflecting the complexity of climate change impacts on Southern Ocean ecosystems. It explains the international framework underpinning this work and identifies issues for consideration in policy development.

The project team has contributed to a new risk assessment framework for spatially managing the krill fishery in CCAMLR. It was presented to WG-EMM at its 2016 mid-year meeting and progressed to adoption at the October 2016 meeting of CCAMLR.

The ACECRC conference on Marine Ecosystem Assessment for the Southern Ocean will be held in Hobart in April 2018 (www.measo2018.aq). Abstract submissions and registrations have been opened for this conference and SCAR have endorsed a number of activities associated with MEASO, including working towards benchmarking Southern Ocean ecosystems in 2022 and the establishment of a plan for biological observing in the Southern Ocean Observing System (SOOS). A day-long Policy Forum will also be held as part of the Marine Ecosystem Assessment for the Southern Ocean (MEASO 18) conference in Hobart in April 2018.

Dr Andrew Constable has been appointed co-chair of SOOS for the next 3 years ending in 2020 and Dr Jess Melbourne-Thomas has been invited to be a lead author on Polar Regions in the IPCC Special Report on the Oceans and Cryosphere.

3 Education and Training

Education

The ACECRC 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. The ACECRC also supports a small number of students at other tertiary institutions.

ACECRC 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, 60 (FTE) students were involved in PhD studies related to the ACECRC, including 9 commencing students. There were also 13 completions. Of

the 13 PhD students that graduated during the reporting period, 6 are in post-doctoral positions at partner institutions. A further 7 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 outcomes are well above Commonwealth milestone targets for the year.

The ACECRC currently provides financial support to 16 PhD students through top-up scholarships, which are awarded on a competitive basis. Six of these were awarded during the reporting period.

In total, 34 UIAS staff and 52 non-university staff including in-kind contributed staff were involved in PhD supervision.

A total of 128 students were admitted into the Bachelor of Marine and Antarctic Science during the reporting period with 15 completing. This course has superseded both of the Bachelor of Antarctic Science and the Bachelor of Marine Science. There are still currently 4 undergraduate students admitted in the Bachelor of Antarctic Science with a further 2 continuing the Bachelor of Marine Science. A significant number of these undergraduate students are expected to go on to higher degrees at UIAS, with good potential for the ACECRC to attract them into research projects relevant to Antarctica and the Southern Ocean.

Two Honours students commenced since July 2016 with five Honours students graduating during the reporting period (Nicolas Pittman, Priya Kitchener, Aidan Bindoff, Taha Cowen, Veda Malpress). One of the graduated Honours students has since commenced a PhD.

As per the Deed of Variation in March 2016, the Masters educational milestones have been removed from the Education milestones.

The ACECRC will continue to work closely with IMAS to improve visibility of projects and enhance student recruitment.

A list of all ACECRC PhD students, including commencement date, research program, project title, research organisation, country and expected completion date, is provided in Appendix 2.

Two ACECRC PhD students, Mao Mori and Christine Weldrick, were successful in applying to a new intern program being run by the National Institute of Polar Research, which is an ACECRC partner. Both spent four weeks at NIPR in February-March to work with Japanese colleagues on their projects and to follow up on field work undertaken aboard the Japanese vessel Umitsuka Maru.

PhD student Paige Kelly won the AMSA Allen Award (to support an outstanding postgraduate student to attend an international conference, in the field of marine science).

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 ACECRC) present the

course. As of 18 October 2017, 19,942 students have taken the course; 90,559 videos have been watched; and 5,172 classroom posts have been made.

The ACECRC has several structures in place for interaction with and between students. The 'ACEChit Chat' series has been up and running since 7 June 2012 and has been managed by ACECRC PhD students since September 2013. The 'ACEChit 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 facilitate interaction with colleagues and students from different organisations.

In addition, DaSH (Data Science Hobart) fortnightly sessions have been organised by ACECRC students and researchers to build a community of researchers to discuss data, concepts, tools, methods and to solve problems. The weekly IMAS and AAD seminars also allow for students and researchers to have discussions and improve collaborations.

Summer Internship Program

The ACECRC 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 of the 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. The two projects available during the reporting period were:

The ACECRC intern program again attracted over 30 applications this year. The two successful candidates were both from interstate. Jordan Brook from the University of Queensland undertook the R1.1 project supervised by Dr Stephanie Downes (The role of the western lies in altering subduction hotspots and anthropogenic carbon uptake) and Max Rintoul from ANU undertook the R2.2 project supervised by Prof Philip Boyd (Desktop study of methods employed to study the biological effects of multiple oceanic stressors).

The internship program allows for undergraduate students the opportunity to attend seminars, planning meetings, and gain experience working in a supportive, collegiate research environment. The 17/18 internship round is currently advertised.

Work experience

The ACECRC and IMAS established a work experience program during the reporting period to deal with the large influx of requests. Several high school students were hosted by IMAS and the ACECRC 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.

4 Utilisation

The ACECRC 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 levels 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 ACECRC's essential and other research participants.

During the reporting period, the ACECRC hosted two key events, a symposium and a research user forum for end-users, attended by 217 delegates.

ACECRC Symposium

The ACECRC held its 2016 Symposium in Hobart on 4-5 August. The first day featured presentations from end users and researchers around the broad theme of emerging Australian climate science priorities. Speakers included Emma Herd (Investor Group on Climate Change), David Millar (Department of Defence) and Ian Swan (Alpine Resorts Coordinating Council). Day two showcased recent science highlights from each of the ACECRC research projects. Over 180 individuals registered for the event, including staff members, partner agency representatives, departmental staff and MPs.

Canberra Research User Forum

The ACECRC hosted a one-day Research User Forum on 6 April 2017 at the Shine Dome in Canberra. Researchers from the R1.2 and R2.3 programs presented consultation drafts of two new *Position Analysis* publications (see below). Feedback and input from the event helped shape the content of the final documents.

Two new ACECRC Position Analysis publications were produced by the R1.2 and R2.3 programs, in co-ordination with the Public Affairs Manager. Both are available on the ACECRC's [Publications](#) page.

- ***Position Analysis: The Antarctic Ice Sheet and Sea Level***

Scientific contributors: David Gwyther, Sue Cook, Ben Galton Fenzi, Alex Fraser, Felicity Graham, Kazuya Kusahara, Adam Treverrow, Lenneke Jong, Jason Roberts, Steve Rintoul, Anthony Worby, Tasvan Ommen

- ***Position Analysis: Managing Southern Ocean Ecosystems***

Scientific contributors: Andrew J. Constable, Jessica Melbourne-Thomas, Rowan Tebilo, Anthony J. Preiss, Marcus Howard

CRC Showcase

The ACECRC hosted a display at the 2017 CRC Showcase for the CRC Association's Annual Conference ('Collaborate | Innovate') from May 23-25 in the Great Hall of Parliament House in Canberra. The event provided an opportunity for elected representatives, senior departmental staff and foreign embassy staff to learn about current CRC research activities. The ACECRC and AAD jointly funded irradiation of three new demonstration ice cores, to be the primary focus of the display. Dr Tessa Vance attended, and spoke with attendees about her recent research outcomes on Australia-Antarctic climate teleconnections. The demonstration cores, measuring around 80cm, are available for future publicity and outreach activities by both AAD and ACECRC.

Dr Tom Remenyi was among five CRC early career researchers from around Australia chosen to deliver a short presentation about their work at the Conference dinner. Finalists in the Early Career Researcher Showcase were selected on the basis of a 30-second video outlining their research. Dr Remenyi's video is available on the CRC website: <http://cra.asn.au/annualconference/showcasing-early-career-researchers/ecr-finals-2017/>.

5 Communications

The ACECRC undertook a significant number of activities during 2016-17 to communicate its work to a broad audience. It has been a busy year, with media metrics indicating that the ACECRC's public profile has continued to grow in Australian and international markets.

Staff participated in a variety of important outreach events, including the 2016 ACECRC Symposium, the CRC Showcase, a Canberra Research User Forum and a variety of educational events such as the popular Festival of Bright Ideas in Hobart.

Participation by staff in online self-publishing continued to grow, with two ACECRC researchers now ranked among the top five University of Tasmania contributors to The Conversation.

These and other activities have enabled the ACECRC to meet or exceed most targets set out in the *Communications Strategy* relating to media coverage, publications and outreach. A key area for improvement remains traffic volume to ACECRC's main website, where metrics remained stable at roughly 70-80 page views per day, but the annual growth target of 20% was not met.

Media Highlights

The ACECRC's media monitoring and analytics indicate that Australian audience reach continued to grow during the reporting period, up by about 10% on the previous period. This may be attributable, in some measure, to an increase in the volume of cold calls to the ACECRC from journalists seeking comment on breaking stories – one of the benefits of being able to provide consistent, responsive and high quality scientific expertise.

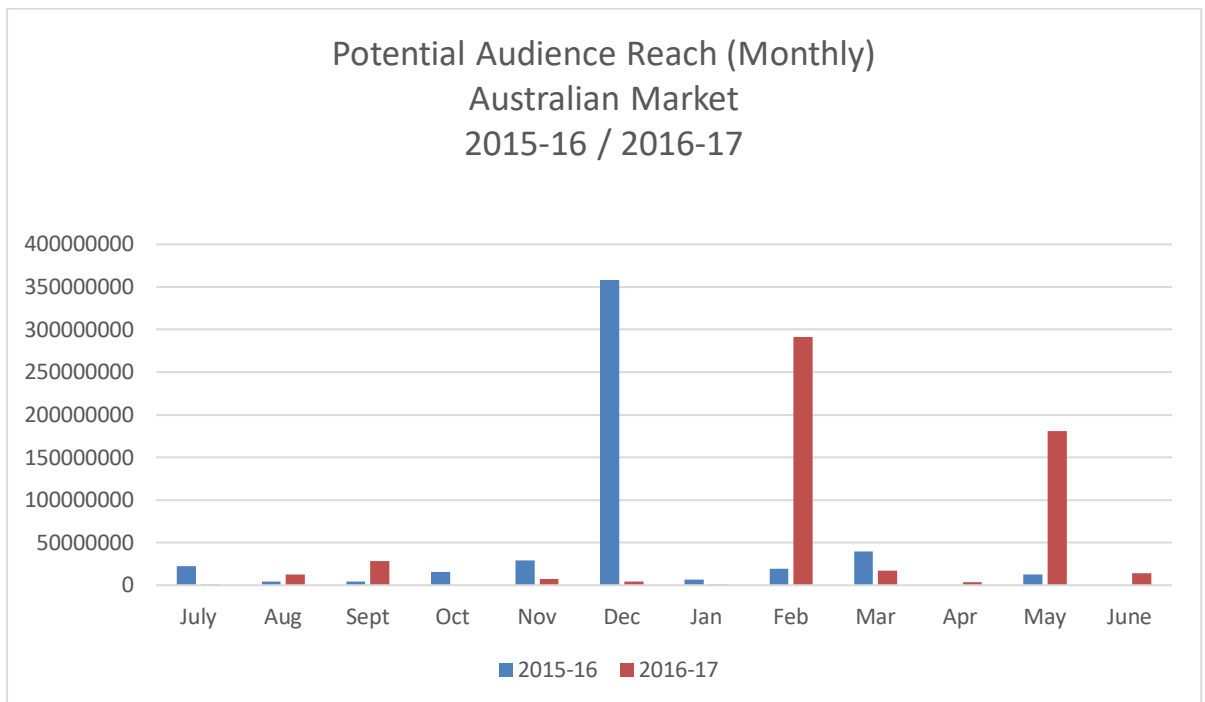
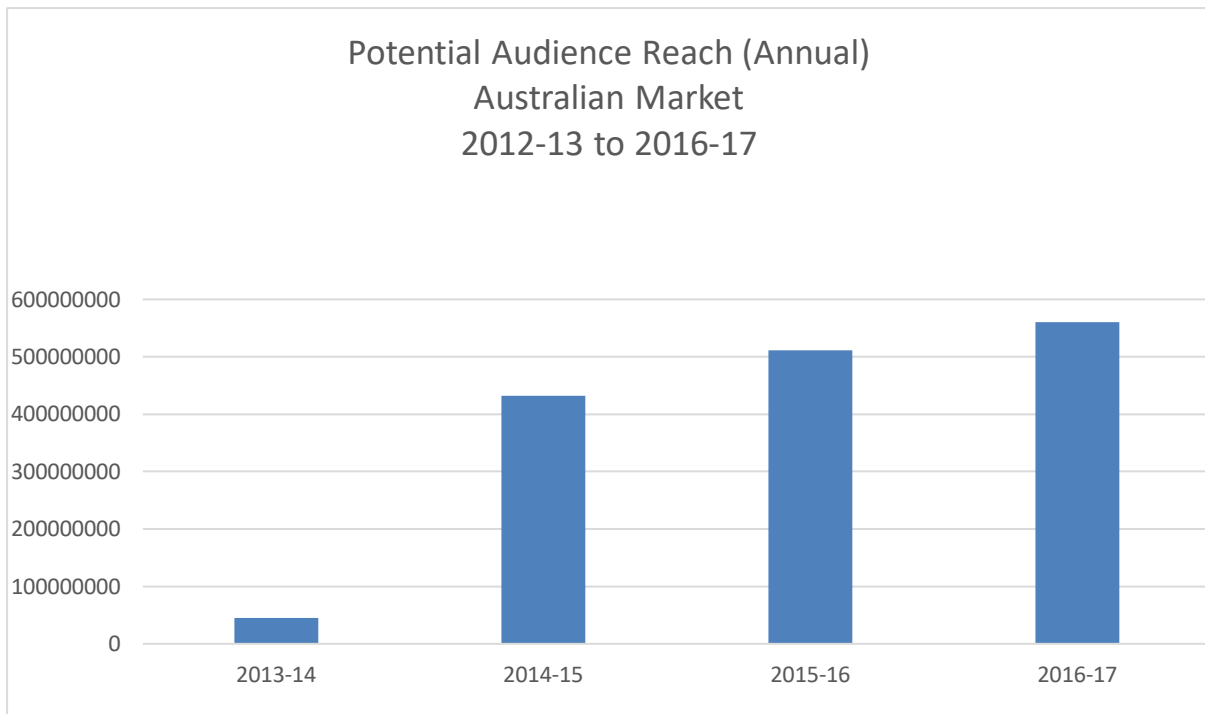
Two large spikes were observed in media coverage during the period. The first, in February 2017 was driven mostly by interest in the record low Antarctic summer sea ice extent. The second, in May appears mostly linked to international interest in a large, green coastal algal bloom in Antarctic first observed by ACECRC staff member, Dr Jan Lieser. Other notable media coverage during the period focused on:

- The imminent, and later observed, calving of a large iceberg from Larsen C Ice Shelf
- Escalating fire danger in the Tasmanian Wilderness World Heritage Area
- Continued coverage of Totten Glacier thinning
- The “Homeward Bound” women in polar science voyage

Audience Reach

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 ACECRC and/or its staff members. Figures are calculated using an industry standard model based on publicly available circulation data.



Media Highlights

TasWeekend: Antarctic voyage to promote women in scientific and political spheres, The Mercury, 27 November 2017
<http://www.the mercury.com.au/news/tasmania/tasweekend-antarctic-voyage-to-promote-women-in-scientific-and-political-spheres/news-story/17c7dc1d646880bf6b337e5c58625f>

How much longer can Antarctica's hostile ocean delay global warming?, Nature.com, 16 November 2016
<http://www.nature.com/news/how-much-longer-can-antarctica-s-hostile-ocean-delay-global-warming-1.20978>

Fire risk in World Heritage area needs more research ahead of longer, drier summers, ABC News, 20 December 2016
<http://www.abc.net.au/news/2016-12-20/world-heritage-risk-fire-threat-needs-more-research/8136788>

Wilderness fires pose 'major challenge', says new TWCHA report, The Mercury, 20 December 2016
<http://www.the Mercury.com.au/news/politics/wilderness-fires-pose-major-challenge-says-new-twcha-report/news-story/64e0bfefdb83410770c28d03a63bb4e3>

Frozen sea spart to allow explorers a glimpse of dying glacier's secrets, The Australians, 17 December 2016
<http://www.theaustralian.com.au/news/nation/frozen-sea-spart-to-allow-explorers-a-glimpse-of-dying-glacier-secrets/news-story/1d6b8bc1f0096d3ffc3c53a4ac33b4a9>

One Of Antarctica's Biggest Glaciers Is Melting Because Of Warm Sea Water, The Huffington Post, 20 December 2016
<http://www.huffingtonpost.com.au/2016/12/19/one-of-antarctica-s-biggest-glaciers-is-melting-because-of-warm/>

Interview: glaciologist Jason Roberts in Antarctica, The Guardian, 20 January 2017
<https://www.theguardian.com/world/video/2017/jan/20/interview-jason-roberts-antarctica-video>

Antarctica ice berg Larsen C held together by 20km of connected ice shelf, The Examiner Newspaper, 11 Jan 2017
<http://www.examiner.com.au/story/4398792/ice-berg-poised-to-crack-from-antarctic-ice-shelf/>

Unfrozen in Time, The Huffington Post, February 2017
http://stories.huffingtonpost.com.au/antarctica/?utm_hp_ref=au-homepage

Listen up: a plan to help scientists get the irresearch heard by decision-makers, Australasian Science, Feb 2017. Quoted: Dr Ben Galton Fenzi

As Australia scorches, sea ice spread around Antarctica hits a record low, Sydney Morning Herald, 19 Feb 2017. Quoted: Dr Jan Lieser

Antarctic sea floor film to support application to make Sabrina Coast a Marine Protected Area, ABC Radio Australia, 27 February 2017. Quoted: Dr Andrew Constable

Antarctic sea ice 'obliterate' previous minimum record, in remarkable reverse, Sydney Morning Herald, 01 March 2017. Quoted: Dr Jan Lieser

UN records Antarctica's highest ever temperature, Ecnnews, 02 March 2017

'Huge experiment': The continent that climate change has not forgotten, Sydney Morning Herald, 04 March 2017. Quoted: Dr Jan Lieser

[Antarctic sea ice is lean and green](#), NASA Earth Observatory, 09 March 2017.

Quoted: Dr Jan Lieser

[GLOBALSHOCK: The Antarctic is turning LUMINOUS GREEN](#), The Express, 15 March 2017

[Weird green ice floats in Antarctic harbour](#), Huffington Post, 15 March 2017

[Happy Saint Paddy's Day?! Algae Turns Antarctic Ice Green](#), Sputnik News, 15 March 2017

[Investigator heads to Southern Ocean for climate research](#), IMOS, 19 March 2017.

Quoted: Prof Tom Trull

[Tasmanian economy gains \\$180m from Antarctic sector, but scientists worried](#), ABC News, 04 April 2017. Quoted: Prof Tony Worby

[Antarctic's sleeping ice giant could wake soon](#), Nature, 12 April 2017. Quoted: Dr Tasvan Omen

[Satellite eye on Earth – March 2017 in Pictures](#), The Guardian, 26 April 2017. Quoted: Dr Jan Lieser

[Ominous signs for Larsen C Ice Shelf](#), The Science Show, ABC Radio National, 10 June 2017. Quoted: Sue Cook

Professional Development

Efforts continued during the period to provide practical media skills training to staff members, to encourage greater participation in the public arena and to grow the ACECRC's stable of communicators. This included a one-day media training session for students and postdoctoral researchers, jointly hosted by communications personnel from IMAS and ACECRC. Further sessions are planned for late 2017. The Public Affairs Manager has also conducted regular one-on-one coaching sessions with staff and students to assist with preparation for media interviews and public appearances.

Dr Sue Cook was among 10 early career researchers shortlisted for a place in the ABC's scientist-in-residence program, *Top Five Under 40*. Unfortunately, Dr Cook did not make the final five, but was later interviewed by one of the panelists, Robyn Williams, about her work for ABC Radio National's Science Show.

Online communications

The ACECRC communications strategy sets out a target of 20% year-on-year growth in visitor volume for the website. This target was not met during 2016-17, with traffic to the website remaining roughly the same as the previous year, at 70-80 page views per day. The Public Affairs Manager is reviewing the underlying factors, and has sought external advice on recommended means for driving traffic growth (search engine optimisation, Google Adwords, etc).

The ACECRC is actively managing, or developing, two other web domains:

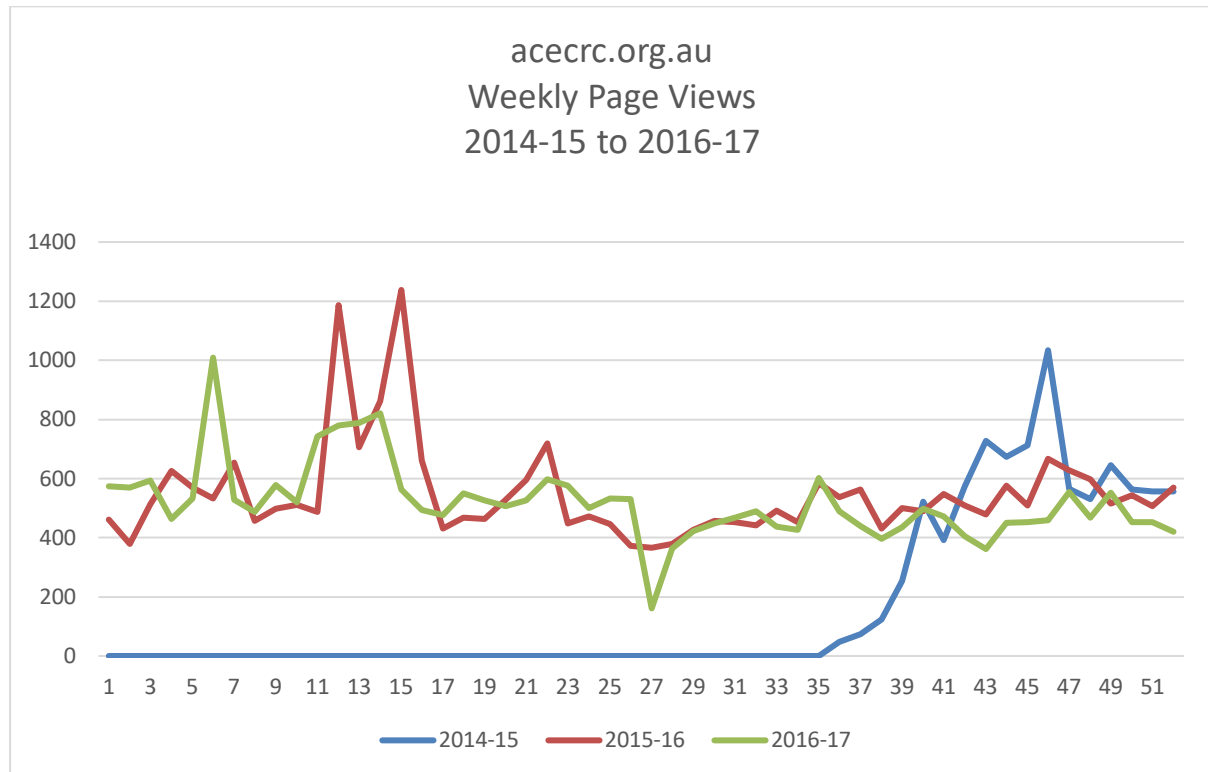
climatefuture.s.org.au

A standalone website has been developed to showcase the work of the Climate

Future s group. The site, containing details of Climate Future s proje cts, media relea ses and other materials, was launc hed at the ACECRC Symposium in August.

www.measo2018.org

A central information point for the planned MEASO 2018 conference to be hosted by the ACECRC.



6 SME Engagement

Over the last year we have successfully completed two projects in collaboration with SGS Economics and Planning, an SME as well as being a formal ‘Other Participant’ in the ACECRC. The first was a small, rapid project conducting a cost effectiveness analysis for the NSW Office of Environment and Heritage. Shortly after, the ACECRC contributed on a much larger piece of work, the Alpine Resort Futures Vulnerability Assessment (Social and Economic).

In both cases, the ACECRC provided 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 (e.g. reviewing existing literature; providing expert analysis or advice on climate change and its impacts).

Both projects have been successfully completed and the working relationship has proven to be productive, with interest from both the ACECRC and SGS Economics and Planning looking forward to future collaborations.

The ACECRC 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 serving commercial and scientific activity in the Antarctic, sub-Antarctic and the Southern Ocean.

7 Intellectual property management/ Commercialisation

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

The ACECRC 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 value of the ACECRC's IP is derived from the products and services developed by the ACECRC, which wrap around ACECRC's core research outputs. These products and services have evolved over the ACECRC's history in close consultation with end-users to ensure that they are relevant to end-users.

In particular, the ACECRC is playing an important role in improving the parameters that feed into climate change and sea level rise projections and underpin any adaptation response. The ACECRC 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 ACECRC remains a very significant contributor to the IPCC Assessment process. ACECRC scientists are engaged in discussions on the timing and process for the Sixth Assessment Report which is due to be finalised in time for the first UNFCCC global stocktake when countries will review progress towards the ir goal of keeping global warming to well below 2°C while pursuing efforts to limit it to 1.5°C.

Two areas of ACECRC activity have attracted a level of commercial interest. These are the impacts of sea-level rise on the Australian coastline and fine-scale climate change modelling.

- The ACECRC sea-level rise impacts project delivered a web-based tool, *Canute* that enables end users to assess the likelihood of coastal flooding under different sea level rise scenarios.
- The Climate Futures for Tasmania project was developed via a funding model, which sits outside the CRC program. It was a requirement of the funding model that the data and outputs be placed in the public domain. The Climate Futures Tasmania reports are being utilised by a wide variety of users, including State and local government, and private businesses including consulting firms.

The ACECRC did not envisage securing any commercial return on either of these projects, both of which have now been successfully transitioned to other organisations for ongoing management. Any further development of the products would require substantial additional funding and should the private sector pursue such a strategy, there is no expected return to the ACECRC.

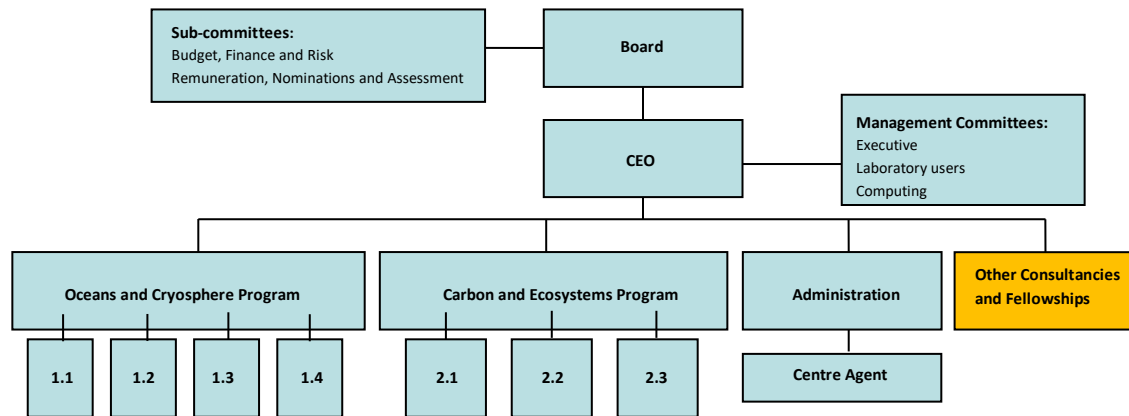
The ACECRC presently archives its data and meta data with the Australian Antarctic Data Centre. This is a requirement of any project receiving support through the Australian Antarctic Science proposal process.

The ACECRC does not hold any patents in Australia or overseas.

8 Governance – board, committee and key staff

The ACECRC 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 ACECRC 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 ACECRC is as follows (as at 30 June 2017):



BOARD #
 Katherine Woodthorpe – Chair
 Tony Coleman – Independent
 Gordon Hagart – Independent
 Nick Gales – AAD
 Graham Hawke – BoM
 Ken Lee – CSIRO
 Brigid Heywood – UTAS
 Malcolm Thompson – Dept. of Environment
 Tony Worby – Ex officio
 Gwen Fenton – Ex officio
 Mark Kelleher – Board Secretary

MANAGEMENT TEAM ~
 Tony Worby – CEO (Chair)
 Mark Kelleher – Deputy CEO
 David Reilly – Public Affairs Mgr
 Wenneke ten Hout (0.8) – Admin Mgr
 Claire Rutherford (0.4) – Admin

EXECUTIVE COMMITTEE #
 Tony Worby – CEO (Chair)
 Mark Kelleher – Deputy CEO
 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
 Jason Roberts – Co-chair, Computing Committee

LAB USERS COMMITTEE #
 Pamela Quayle – ACE Lab Mgr (Chair)
 Nils Jansen – Lab 304
 Pier v/d Merwe – Lab 306
 Diana Davies – Lab 308
 Adam Treverrow – Lab 310
 Andrew Moy – Lab 312D
 Meredith Nation – Lab 312
 Toby Bolton – IMAS Lab Mgr

COMPUTING COMMITTEE #
 Jason Roberts – Co-Chair
 Ben Galton-Fenzi – Co-Chair
 Wenneke ten Hout – ACE Admin
 Stuart Corney – Staff Rep
 UTAS IT Rep
 Brendon Davey – NECTAR Rep/Unix
 Chen Zhao – Student rep

~ 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 Chairman, (ii) one representative from each Australian Essential Participant, (iii) one representative of the Tasmanian Government, (iv) one representative of the Australian Department of Environment and Energy, (v) two persons independent of the Participants and (vi) the CEO and the AAD Chief Scientist who are ex-officio members.

During the reporting period, Mr Malcolm Thompson commenced on the Board after the Department of the Environment and Energy representative seat was vacated late 2015 by Mr Steven Kennedy. Dr Kenneth Lee resigned from the CSIRO late 2016 and was replaced on the ACECRC Board by Dr Andreas Schiller. Mr Greg Johannes resigned from the Board late 2016 with Mr Mark Sayer appointed as the Tasmanian Government representative from June 2017. Dr Rob Murdoch from NIWA joined the May 2017 Board meeting as an observer.

Board meetings are held every quarter. During this reporting period, meetings were held on 3 August 2016, 17 November 2016 (including Annual General Meeting), 24 February 2017 and 12 May 2017.

Board Members (in alphabetical order)

Name	Role	Key Skills	Independent/ Organisation	Number of meetings
Mr Tony Coleman	Board Member	<ul style="list-style-type: none"> - High level executive management experience in private enterprise - Financial audit, actuarial and risk management expertise - Commercial objectivity and independence from CRC participants 	Independent	3/4
Dr Gwen Fenton	Ex-Officio	<ul style="list-style-type: none"> - High level science planning and coordination experience - High level national and international experience in science and policy - High level science expertise in stable isotope analysis of marine food webs 	Australian Antarctic Division (Essential Participant)	4/4
Dr Nick Gales	Board Member	<ul style="list-style-type: none"> - High level national and international experience in science and policy - High level science expertise in applied marine mammal conservation science - Australian Marine Mammal Centre leadership 	Australian Antarctic Division (Essential Participant)	3/4
Mr Gordon Hagar	Board Member	<ul style="list-style-type: none"> - Extensive experience in financial services including investment - Extensive experience in leadership and management at senior levels 	Independent	4/4
Mr Graham Hawke	Board Member	<ul style="list-style-type: none"> - Extensive experience in research leadership and management at senior & institutional levels - Broad relevant domain expertise in climate and atmospheric science 	Bureau of Meteorology	4/4

Name	Role	Key Skills	Independent/ Organisation	Number of meetings
Prof Brigid Heywood	Board Member	- Extensive experience in research leadership and management at senior & institutional levels - Broad and extensive expertise in biological sciences	University of Tasmania (Essential Participant)	3/4 (commenced November 2015)
Mr Greg Johannes	Board Member	- High level executive management experience in both policy and operational roles in the public and private sector - Substantial and wide ranging Board experience in both the research and community sector - Lead State Government representative in national negotiations under Council of Australian Governments (COAG) on climate change policy, legislation and regulation	Tasmanian Government (Other Participant)	1/2 (resigned December 2016)
Mr Malcolm Thompson	Board Member	- High level management skills - Extensive experience in government and public policy	Department of Environment (Essential Participant)	3/4
Dr Kenneth Lee	Board Member	- Extensive experience in research leadership and management at senior & institutional levels - Broad relevant domain expertise in climate and marine science, in particular development and application of emerging technologies in ocean sciences	Commonwealth Scientific and Industrial Research Organisation (CSIRO) (Essential Participant)	1/4 (until October 2016)
Dr Andreas Schiller	Board Member	- High level national and international experience in science and policy	Commonwealth Scientific and Industrial	2/3 (commenced)

Name	Role	Key Skills	Independent/ Organisation	Number of meetings
		<ul style="list-style-type: none"> - High level leadership and administrative experience - High relevant expertise in climate change, coupled-ocean atmosphere models, and ocean forecasting systems. 	Research Organisation (CSIRO) (Essential Participant)	November 2016)
Dr Tony Worby	Ex-Officio	<ul style="list-style-type: none"> - High level leadership and administrative experience - Extensive experience in government and public policy - High relevant domain expertise in climate and marine science and policy 	ACECRC	4/4
Dr Katherine Woodthorpe	Chair	<ul style="list-style-type: none"> - 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 25 October 2016 and 27 April 2017. 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 ACECRC Board Chair, and has a majority of independent members. The primary objective of the Nominations, 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 2016 to review the CEO's KPIs.

The Executive Committee

The ACECRC executive brings together senior administrative staff and program leaders on a quarterly basis to report on progress against milestones and discuss priority activities. Meetings were held on 20 July 2016, 8 November 2016, 6 February 2017, and 18 May 2017.

Name	Role	Key Skills	Organisation
Prof Nathan Bindoff	Project Leader 1.1, Climate Futures; Director Tasmanian Partnership for Advanced Computing (TPAC)	Computing/research	ACE CRC/TPAC
Dr Andrew Constable	Program Leader, Carbon and Ecosystems Program	Research	ACE CRC/AAD
Mr Mark Kelleher	Deputy CEO (from October 2014)	Finance/Governance	ACECRC
Mr David Reilly	Public Affairs Manager (from September 2014)	Communications/Media	ACECRC
Dr Stephen Rintoul	Program Leader, Oceans and Cryosphere Program	Researcher	ACE CRC/C SIRO
Dr Jason Roberts	Researcher, Co-chair ACECRC Computing Committee	Research/computing	ACE CRC/AAD
Ms Wennette Hout	Administration Manager	Administration/Education	ACECRC

Name	Role	Key Skills	Organisation
Prof Thomas Trull	Program Leader, Carbon and Ecosystems Program	Researcher	ACE CRC/CSIRO
Dr Tasvan Ommen	Program Leader, Oceans and Cryosphere Program	Research	ACE CRC/AAD
Dr Tony Worby	CEO	Management/Governance	ACE CRC

Laboratory Users Committee

The Laboratory Users Committee represents the ACE CRC laboratory's broad multidisciplinary user community and advises management on all issues affecting users of the facilities. Ms Pamela Quayle is Chair for this committee. During the reporting period, the laboratory users' committee met on 1 February 2017 with an additional smaller lab meeting of the trace metal team and the ice core group held regularly throughout the reporting period. At least one person of each research group attends these meetings with any students that work in the laboratories also invited. A separate hydrofluoric acid first aid response workshop was held on 22 February 2017.

Name	Role	Organisation
Mr Toby Bolton	Laboratory Manager	IMAS
Mr Nils Janse n	Laboratory technician – lab 304	IMAS
Dr Diana Davies	Researcher – lab 308	ACE CRC
Dr Andrew Moy	Researcher – lab 312	AAD
Ms Meredith Nation	Laboratory assistant – ice core group – lab 312	AAD
Ms Pamela Quayle	Laboratory Manager (from June 2015) – Chair	ACE CRC
Dr Adam Tveerow	Researcher – lab 310	ACE CRC
Dr Pier van der Merwe	Researcher – lab 306	ACE CRC

Computing Committee

The ACE CRC Computing Committee supports the science and education programs of the ACE CRC by providing advice on information technology, infrastructure and management. The ACE CRC Computing Committee advises the ACE CRC Executive Committee and CEO. The ACE CRC Computing Committee will meet every quarter two weeks prior to the scheduled ACE CRC Executive meetings or more frequently as necessary.

Member	Role	Organisation
Mr Antony Cave / Mr Ze Feng Low	UTIAS IT representative	UTIAS
Dr Stuart Comey	Researcher	ACE CRC
Brendon Davey	NECTAR representative / Unix	TPAC
Dr Ben Galton-Fenzi (co-chair)	Researcher	AAD
Dr Jason Roberts (co-chair)	Researcher	AAD
Ms Wenneke ten Hout	Administration Manager - secretary	ACE CRC
Ms Chen Zhao	PhD student representative	UTIAS

Key Staff

Staff Member	Role	Organisation	% Time
Prof Nathan Bindoff	IPCC AR5 – coordinating lead author and Project Leader – 1.1	ACE CRC / IMAS	50%
Dr Phillip Boyd	Project Leader – project 2.2	ACE CRC / IMAS	20%
A/Prof Andrew Bowie	Project Leader – project 2.1	ACE CRC / IMAS	50%
Prof Richard Coleman	Project Leader – project 1.2	ACE CRC / IMAS	20%
Dr Andrew Constable	Program Leader – Carbon and Ecosystems	ACE CRC / AAD	65%
Dr Mark Curran	Project Leader – project 1.4	ACE CRC / AAD	80%
Dr Ben Galton-Fenzi	Project Leader – project 1.2	ACE CRC / AAD	80%
Dr So Kawaguchi	Project Leader – project 2.2	ACE CRC / AAD	60%
Mr Mark Kelleher	Deputy CEO (from October 2014)	ACE CRC	100%
Dr Rob Massom	Project Leader – project 1.3	ACE CRC / AAD	80%
Dr Jessica Melbourne-Thomas	Project Leader – project 2.3	ACE CRC / AAD	70%
Dr Klaus Meiners	Project Leader – project 2.2	ACE CRC / AAD	80%
Mr David Reilly	Public Affairs Manager (from September 2014)	ACE CRC	100%
Dr Stephen Rintoul	Program Leader – Oceans and Cryosphere	ACE CRC / CSIRO	50%
Ms Wenneke ten Hout	Administration Manager	ACE CRC	80%

Staff Member	Role	Organisation	% Time
Prof Tom Trull	Program Leader – Carbon and Ecosystems	ACECRC/CSIRO	50%
Dr Tas van Ommen	Program Leader – Oceans and Cryosphere	ACECRC/AAD	60%
Dr Guy Williams	Project Leader – project 1.3	ACECRC/IMAS	50%
Dr Tony Worby	CEO	ACECRC	100%

9 Participants

The commitment of the seven core partners to the ACECRC remains strong. Our two international core partners, NIWA and AWI, are closely engaged with the ACECRC. A new ACECRC/AWI visitor exchange program has been developed and commenced 2017. A NIWA representative participated in the ACECRC Symposium in August 2016.

ACECRC 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	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

Participant's name	Participant type	ABN or ACN	Organisation type
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
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

Participant's name	Participant type	ABN or ACN	Organisation type
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.

10 Collaboration

ACECRC 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 ACECRC collaborates with 100 domestic and international organisations. Of these, there are 27 Australian, 3 New Zealand, 9 Asian, 24 North American, 1 South American, and 36 European.

Of the 27 domestic collaborations, there are 6 Australian Government Institutions, 5 State Government Institutions, 12 universities, 1 industry/private sector, and 3 others.

Of the 73 international collaborators, there are 36 universities, 2 from industry/private sector, and 35 research institutions/organisations.

In particular during the year, the ACECRC hosted or led a number of major international workshops and other similar events, including:

- The ACECRC, along with the Antarctic Gateway Partnership and IMAS, successfully hosted the 2017 Asia-Pacific Regional Ocean Modelling System Workshop, 17-21 October 2016. This workshop was attended by nearly 100 international scientists and strongly promoted Tasmania as a hub of polar ocean modelling.
- Hosted by CRC partner, AWI, ACE scientists led a highly successful international workshop to further develop a strategy for observing the oceans under Antarctic sea ice and ice shelves.

11 Financial Management

The ACECRC completed the 2016-17 financial year with a cash balance of \$1,988k. This reflects the deferral of \$648k of capital equipment purchases into the 2017-18 financial year, accumulated interest income and external funds of \$453k, together with re-profiling of Expenses to reflect adjusted voyage schedules. The overall five year programme remains on track in respect of milestone delivery.

Table 1

	Totals for 2016-17				Projected Totals for 5 years			
	Actual	Agr'mt	Diff	%Diff	Actual/Proj	Agr'mt	Diff	%Diff
Employee Expenses	4,010	3,750	260	7	18,309	16,642	1,667	10
Supplier Expenses	1,289	1,847	-558	-30	5,917	7,680	-1,763	-23
Capital	0	112	-112	-100	1,891	973	918	94
Other Expenses	0	0	0	0	200	753	-553	-73
TOTAL EXPENSES	5,299	5,709	-410	-7	26,317	26,048	269	1

The variations in Expenses in 2016-17 were due mainly to deferral of \$648k of capital equipment into the 2017-18 financial year, with the most significant component of this being deferral of \$312k purchases of Argot floats (all of 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. Additional interest and other external income of \$207k, provided funding for additional contract extensions for staff where this provided improved delivery capability for milestones.

Cash flow management actions taken during the first three years meant that there is no requirement for a \$553k overdrift facility (included in Other Expenses) to cover previously forecast deficits in the middle years of this term.

Projected 5 year totals show that additional external and interest income totalling \$822k, along with \$845k in net savings in supplier/capital expenses will underpin a number of contract extensions for research staff, reflected in the forecast employee expenses variance of \$1,667k, 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 (FIE) of Staff-kind Contributions	
	Amount Contributed (FIE)	Amount Committed (FIE)
Australian Antarctic Division	21.7	28.6
University of Tasmania	6.4	6.6
CSIRO	5.7	3.5
Laboratoire d'Etudes en Géophysique et Océanographie Spatiales (LEGOS)	0.7	1.2

SGS Economics and Planning Pty Ltd	0.12	0.2
Institute of Low Temperature Science (ILTS)	1.2	1.4
Tokyo University of Marine Science and Technology (TUMSAT)	0.45	0.5

<i>Participants</i>	<i>Table 1(b) Non-staff in-kind Contributions</i>	
	<i>Amount Contributed (\$'000)</i>	<i>Amount Committed (\$'000)</i>
Australian Antarctic Division	3,829	17,998
CSIRO	2,419	200
First Institute of Oceanography (FIO)	3,850	2,750
Institute of Low Temperature Science (ILTS)	5,491	185
National Institute of Water and Atmospheric Research (NIWA)	10	1,010

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 contributions.

The large AAD variance in non-staff contributions included two projects which did not go ahead as originally planned in this season. Ice core drilling (Mount Brown South) and Marginal Ice Zone (MIZ) sea-ice voyage. The ice core drilling is scheduled for season 2017-18, while the MIZ voyage is deferred and may not be conducted, with the related milestone to be achieved via contributions from other voyages. The NIWA variance is due to a planned voyage that is now scheduled in 2017-18. The larger than projected contribution from CSIRO was associated with the SR3 voyage being conducted on the *RV Investigator*, while the ILTS and FIO variances were associated with an additional voyage and ship-days.

For the Research Program overall, the variations in contributions in 2016/17 are not expected to affect achievement of current or future milestones.

<i>Research Program</i>	<i>Total Expenditure (\$'000)</i>	<i>Amount Budgeted (\$'000)</i>
Research Program 1:		
Cash	2,787	3,062
Non-Staff in-kind	17,052	23,476
In-kind Staff (FTE)	30.74	33.70
Research Program 2:		
In-kind Staff	20.85	23.10

12 CRC future plans and transition arrangements

The current funding for the ACECRC concludes in June 2019. Recent changes in CRC guidelines preclude a re-bid for funding under this mechanism. In order to enable a smooth transition and minimise the risk of loss of key staff it will be important to have funds for a new Centre identified in the May 2018 Federal budget.

The core Australian partners in the ACECRC recognise the value of the CRC model in driving collaboration, both nationally and internationally, and through the ACECRC Board will prosecute the case to establish a centre that endures beyond 2019.

The Department of Environment and Energy's commissioning of a review of the Australian Government's Antarctic Science funding model has presented a unique opportunity to view Antarctic science funding and related mechanisms and the CRC and its partners are contributing to this discussion with government.

Multidisciplinary, cross-institution collaboration has been the cornerstone of the ACECRC's success over the past 25 years. It has not only enabled the CRC to assemble a critical mass of scientists to address the CRC's research goals, it has also leveraged substantial co-investment nationally and internationally. In considering possible models for sustainability, the preferred option will be one that maximises the continuation of multidisciplinary research and optimises the use of research funds through collaboration.

This will not only directly support research but also provide the resources necessary to ensure that campaign-scale research in Antarctica is possible, and that the recent investments in research infrastructure are fully utilised. There is a strong desire and opportunity to attract co-investment from national and international partners, in particular the national Antarctic programs of established and emerging Antarctic nations. Additional external investment from industry for climate-related services may be an additional line of income for any future centre.

Timeline

If the ACECRC collaboration(s) continue via various multilateral or bilateral arrangements a Deed (or Deeds) of Assignment(s) will be created to enable the transition of the relevant IP to the new Centre(s). If the ACECRC is wound-up the IP will be transitioned in accordance with the Commonwealth Agreement and the wind-up plan.

Spin-offs

Irrespective of what form or forms (if any) a future Centre takes it is unlikely to establish any form of commercial spin-off, as there is limited potential for commercial products. While the ACECRC does undertake some consulting activities, this is small in scale, and is not a core business of the research participants. Much of the generated IP will be placed in the public domain. Commercial organisations, whether participants or not, may wish to access this for their own commercial benefit.

Wind Up

Failure to secure the necessary resources, or reach agreement on an alternative model, for an ongoing collaboration will require the CRC to be wound-up. A wind-up plan would be developed approximately 12 months before the end of the CRC and then implemented.

13 Performance review

In July 2016, we received advice from the CRC Programme that revised Programme Guidelines for the CRC Programme were released. In line with the Department's efforts to streamline administrative processes, and in accordance with Part Nine of the revised guidelines, CRC Performance Reviews are no longer required. The Department may commission a review of the ACECRC's performance as necessary and in accordance with the new Reporting and Compliance framework for the CRC Programme.

14 Other activities

Externally Funded Research

The ACECRC continued 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; it commenced 1 July 2016 and 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-scale climate information required to identify the most appropriate adaptation response within each region to maintain grape yield, value and wine quality into the future.

TWWHA – Future fire danger in the Tasmanian Wilderness and World Heritage Area: This project is funded through the Tasmanian Government and commenced on 1 July 2016. The project examines changes in the TWWHA from 1961-2100 relating to: the Forest Fire Index (FFDI), Buttongrass Moorland Fire Danger Index (MFDI), Moist Soil Dryness Index (MSDI) and low rainfall periods, favourable lightning environments, and frequency of typical synoptic weather patterns. The purpose being to improve understanding of how climate change will impact bushfire risk in the TWWHA and thereby have an improved knowledge base for the management of bushfires and prescribed burning regimes under a changing climate.

Climate Change and Bushfire Research Initiative: This project is funded by the Commonwealth Department of the Environment and Energy (NESP) through emerging priorities funding and commenced on 1 December 2016 until 30 June 2018 and is an extension to the above TWWHA project. This project is developing high priority tools and research products to enable protection of the Tasmanian Wilderness World Heritage Area (TWWHA) from adverse impacts of wild fire. Project activities include research into the environmental impact of a range of fire fighting chemicals in different environments along with the ineffectiveness 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 fire fighting chemical use can be achieved by providing guidance on situations where their use is or is not appropriate. The outcome will be to provide management tools to enable the Tasmanian Government to protect the values of the TWWHA through changing their fire regimes.

Cost Benefit Analysis for Future Climate Change Impacts and Adaptation funding: This project is funded by the NSW Government Office of Environment and Heritage in collaboration with SGS Economics and Planning. The project commenced and concluded early 2017 and involved three cost-effectiveness analyses to identify the best steps to adapt to climate change.

Alpine Resort Future Vulnerability Assessment (Social and Economic): This project is funded by the Victorian Department of Environment, Land, Water and Planning and was completed by 30 June 2017. It assessed the vulnerability of economic, social and cultural values of Victoria's six Alpine resorts to climate change.

Review of inflows to Tasmania's hydro-generation catchments: This project was funded by Hydro Tasmania and was completed in late 2016. The aim was to improve Hydro Tasmania's understanding and utilisation of medium term weather and climate predictions.

An Assessment of the Viability of Prescribed Burning as a Management Tool under a Changing Climate: This project was funded by the Department of Police and Emergency Management under the State Emergency Service. It identified the future viability of prescribed burning as a management tool for mitigating bushfire risk under climate change, and was completed in late 2016.

High Resolution Reanalysis for Tasmania Project: This project is funded through the 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. 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 terabyte 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.

During the reporting period, these projects and other related concluded projects published 9 articles in scholarly refereed journals and 6 reports (see below).

Articles in scholarly refereed journals

- Allen, K.J., Nichols, S.C., Evans, R., Allie, S., Carson, G., Ling, F., Cook, E.R., Lee, G. and Baker, P.J. (2017). "A 277 year cool season dam inflow reconstruction for Tasmania, southern eastern Australia." *Water Resources Research* 53(1): 400-414.
- Harris, R.M.B., Kriticos, D.J., Remenyi, T and Bindoff, N. (2016). "Unusual suspects in the usual places: a phylo-climatic framework to identify potential future invasive species." *Biological Invasions*: 1-20.
- Harris, R.M.B., Remenyi, T.A., Williamson, G.J., Bindoff, N.L and Bowman, D.M.J.S. (2016). "Climate-vegetation-fire interactions and feedbacks: trivial detail or major barrier to projecting the future of the Earth system?" *Wiley Interdisciplinary Reviews: Climate Change* 7(6): 910-931.
- Harrison, P.A., Villanocourt, R.E., Harris, R.M.B. and Potts, B.M. (2017). "Integrating climate change and habitat fragmentation to identify candidate seed sources for ecological restoration." *Restoration Ecology*.
- Walsh, K., White, C.J., McInnes, K., Holmes, J., Schuster, S., Richter, H., Evans, J.P., DiLucia, A. and Warren, R.A. (2016). "Natural hazards in Australia: storms, wind and hail." *Climatic Change* 139(1): 55-67.
- White, C.J., Cairns, H., Robertson, A.W., Klein, R.J.T., Lazo, J.K., Kumar, A., Vitar, F., Coughlan de Perez, E., Ray, A.J., Murray, V., Bharwani, S., MacLeod, D., James, R., Fleming, L., Morse, A.P., Eggen, B., Graham, R., Kjellström, E., Becker, E., Pegion, K.V., Holbrook, N.J., McEvoy, D., Dpledge, M., Perkins-Kirkpatrick, S., Brown, T.J., Street, R., Jones, L., Remenyi, T.A., Hodgson-Johnston, I., Buontempo, C., Lamb, R., Meinke, H., Arheimer, B. and Zebiak, S.E. (2017). "Potential applications of subseasonal-to-seasonal (S2S) predictions." *Meteorological Applications*.
- White, C.J., Remenyi, T., McEvoy, D., Trundle, A. and Comey, S.P. (2016). 2016 Tasmania State Natural Disaster Risk Assessment. Hobart, Australia, University of Tasmania.
- White, C.J., Remenyi, T., McEvoy, D., Trundle, A. and Comey, S.P. (2016). 2016 Tasmania State Natural Disaster Risk Assessment: All Hazard Summary. Hobart, Australia, University of Tasmania.

Reports

- Love, P., Fox-Hughes, P., Remenyi, T., Harris, B. and Bindoff, N. (2016) "Impact of climate change on weather-related risk factors in the TWWHA Report" Antarctic Climate and Ecosystems Cooperative Research Centre, Hobart, Australia.
- Press, A.J. (2016) "Tasmania World Heritage Area Bushfire and Climate Report" Tasmania Government, Hobart, Australia.
- Remenyi, T., Harris, R., White C.J., Comey, S.P., Jabour, J., Kelly, S., Norris, K., Denny, L., Julian, R. and Bindoff, N.L (2016) "Projecting volunteer resource requirements under extreme climate future: technical report" Antarctic Climate and Ecosystems Cooperative Research Centre, Hobart, Australia.
- White, C.J., Remenyi, T., McEvoy, D., Trundle, A. and Comey, S.P. (2016) "TSNDRA 2016: Coastal Inundation fact sheet" University of Tasmania, Hobart, Australia.
- White, C.J., Remenyi, T., McEvoy, D., Trundle, A. and Comey, S.P. (2016) "TSNDRA 2016: Heat Wave fact sheet" University of Tasmania, Hobart, Australia.
- White, C.J., Remenyi, T., McEvoy, D., Trundle, A. and Comey, S.P. (2016) "TSNDRA 2016: Pandemic influenza fact sheet" University of Tasmania, Hobart, Australia.

Sea Ice Services

The ACECRC also provided sea ice reporting and analytical services to Antarctic-
bound vessels during the 2016/17 year, including *RSV Aurora Australis*, *l'Astrolabe*, *RV
Investigator* 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 Chinese
National Antarctic Research Expeditions (*RV Xue Long*), the Australian Marine
National Facility (*RV Investigator*) and a commercial fishing operator.

15 Glossary of Terms & Acronyms

A	
AAD	Australian Antarctic Division
AAS	Australian Antarctic Science Program
ABN	Aurora Basin North
ACECRC	Antarctic Climate & Ecosystems Cooperative Research Centre
AGP	Antarctic Gateway Partnership
ANSTO	Australian Nuclear Science and Technology Organisation
AODN	Australian Ocean Data Network
ARC	Australian Research Council
AUV	Autonomous Underwater Vehicle
AWI	Alfred Wegener Institute for Polar Research (Germany)
B	
BoM	Bureau of Meteorology
BAR	Budget, Audit, and Risk Committee
C	
CAMS	Chinese Academy of Meteorological Science (China)
CCAMLR	Convention for the Conservation of Antarctic Marine Living Resources
CLIVAR	Climate Variability and Predictability (component of World Climate Research Programme)
CO	Carbon Monoxide
CO₂	Carbon Dioxide
CPOM	Centre for Polar Oceanography and Modelling (United Kingdom)
CRC	Cooperative Research Centre
CSIRO	Commonwealth Scientific and Industrial Research Organisation
E	
ECU	Edith Cowan University
ENSO	El Niño Southern Oscillation
EPICA	European Project for Ice Coring in Antarctica
F	
FIO	First Institute of Oceanography (China)
G	
GEOSS	Global Earth Observation System of Systems
GEO TRACES	International research programme aiming to improve an understanding of biogeochemical cycles in the oceans
GHG	Greenhouse gases
GOA-ON	Global Ocean Acidification Observing Network
GPS	Global Positioning System

H	
HEOBI	Heard Earth Ocean Biosphere Interaction
I	
ICECAP	Investigating Cryospheric Evolution through Collaborative Aerogeophysical Profiling
IGBP-PAGES	International Geosphere-Biosphere Programme – Past Global Changes
IGS	International Glaciological Society
ILTS	Institute of Low Temperature Science, Hokkaido University (Japan)
IMAS	Institute for Marine and Antarctic Studies, University of Tasmania
IMBER	Integrated Marine Biogeochemistry and Ecosystem Research project
IMOS	Integrated Marine Observing System
IP	Intellectual Property
IPO	Interdecadal Pacific Oscillation
IPCC	Intergovernmental Panel on Climate Change
IWC	International Whaling Commission
L	
LEGOS	Laboratoire d'Etudes en Géophysique et Océanographie Spatiales (France)
M	
MEASO	Marine Ecosystem Assessment for the Southern Ocean
MESOPP	Mesopelagic Southern Ocean Prey and Predators
MIZ	Marginal Ice Zone
MODIS	Moderate Resolution Imaging Spectroradiometer
MSA	Methanesulphonic acid
N	
NIPR	National Institute of Polar Research (Japan)
NIWA	National Institute for Water and Atmospheric Research (New Zealand)
NRA	Nominations, Remuneration and Assessment Committee
O	
ONR	Office of Naval Research
P	
POGO	Partnership for Observations of the Global Ocean
R	
REGS	Research Enhancement Grants Scheme
S	
SAM	Southern Annular Mode
SCAR	Scientific Committee on Antarctic Research
SCOR	Scientific Committee on Oceanic Research

SEAPODYM	Spatial Ecosystem and Population Dynamics Model
SGS	SGS Economic & Planning Pty Ltd
SIPEX-II	Sea-ice Physics & Ecosystem Experiment
SME	Small and Medium Enterprises
SOCAT	Surface Ocean Carbon Atlas
SOCOM	Southern Ocean Carbon and Climate Observations and Modeling Project
SOFS	Southern Ocean Flux Station
SOOS	Southern Ocean Observing System
SOTS	Southern Ocean Time Series

T

TPAC	Tasmanian Partnership for Advanced Computing
TSANDRA	Tasmanian State Natural Disaster Risk Assessment
TUMSAT	Tokyo University of Marine Science and Technology
TWWHA	Tasmania Wilderness World Heritage Area

U

UCIA	University of California, Los Angeles
UNFCCC	United Nations Framework Convention on Climate Change
UTAS	University of Tasmania

V

VIMS	Virginia Institute of Marine Science
VUB	Vrije Universiteit Brussel

W

WHOI	Woods Hole Oceanographic Institution
WOCE	World Ocean Circulation Experiment

Appendix 1– list of publications

Book Chapters

- Bluhm, B.A., Swadling, K.M. and Gradinger, R. (2016). Sea ice as a habitat for macrograzers. *Sea Ice: Third Edition*: 394-414.
- Constable, A., Meredith, M.P., Ducklow, H.W., Murphy, E.J., Linse, K and Kawaguchi, S. (2016). Impacts and effects of ocean warming on Antarctic ecosystems and species. *Explaining ocean warming: Causes, scale, effects and consequences*. Laffoley, D., and Baxter, J.M. (editors). Gland, Switzerland, IUCN: 337-355.
- Jabour, J. (2017). Search and rescue in Antarctica. *Handbook on the politics of Antarctica*. UK, Edward Elgar.
- Kawaguchi, S. (2016). Reproduction and Larval Development in Antarctic Krill (*Euphausia superba*). *Biology and Ecology of Antarctic Krill*. Siegel, V. Cham, Springer International Publishing: 225-246.
- Sturm, M. and Massom, R.A. (2017). Chapter 3: Snow in the sea-ice system: friend or foe? *Sea Ice, 3rd Edition*. (editor), D.T., Wiley-Blackwell, New York (USA) & Oxford (UK): 664.

Articles in Scholarly Referenced Journals

- Abram, N.J., Mc Gregor, H.V., Temeey, J.E., Evans, M.N., McKay, N.P., Kaufman, D.S. and Conso rtium, P.k. (2016). "Early onset of industrial-era warming across the oceans and continents." *Nature* 536(7617): 411-418.
- Ahmad Ishaq, N.H., Clementson, L.A., Erikson, R.S., van den Eenden, R.L., Williams, G.D. and Swadling, K.M. (2017). "Gut contents and isotopic profiles of *Salpa fusiformis* and *Thalia democratica*." *Marine Biology* 164(6): 144.
- Alexander, P., Duncan, A., Bose, N. and Williams, G. (2016). "Modelling acoustic propagation beneath Antarctic sea ice using measured environmental parameters." *Deep Sea Research Part II: Topical Studies in Oceanography* 131: 84-95.
- Arie nzo, M.M., Mc Connell, J.R., Chellman, N., Criscitello, A.S., Curran, M., Fritzsch e, D., Kipfstuhl, S., Mulvaney, R., Nolan, M., Opel, T., Sigl, M. and Steffensen, J.P. (2016). "A Method for Continuous ²³⁹Pu Determinations in Arctic and Antarctic Ice Cores." *Environmental Science and Technology* 50(13): 7066-7073.
- Amdt, S., Meiners, K.M., Ricker, R., Krumpfen, T., Kattlein, C. and Nicolaus, M. (2017). "Influence of snow depth and surface flooding on light transmission through Antarctic pack ice." *Journal of Geophysical Research: Oceans* 122(3): 2108-2119.
- Arthur, B., Hindell, M., Bestler, M., De Bruyn, P.J.N., Tra than, P., Goebel, M. and Lea, M.-A. (2017). "Winter habitat predictions of a key Southern Ocean predator, the Antarctic fur seal (*Arctophalus gazella*)." *Deep Sea Research Part II: Topical Studies in Oceanography* 140(Supplement C): 171-181.
- Asay-Davis, X.S., Comford, S.L., Durand, G., Galton-Fenzi, B.K., Gladstone, R.M., Hilmar Gudmundsson, G., Hattemann, T., Holland, D.M., Holland, D., Holland, P.R., Martin, D.F., Mathiot, P., Pattyn, F. and Seroussi, H. (2016). "Experimental design for three interrelated marine ice sheet and ocean model intercomparison projects: MISMIP v. 3 (MISMIP+), ISOMIP v. 2 (ISOMIP+) and MISOMIP v. 1 (MISOMIP1)." *Geoscientific Model Development* 9(7): 2471-2497.
- Ashcroft, M.B., King, D.H., Raymond, B., Turnbull, J.D., Wasley, J. and Robinson, S.A. (2017). "Moving beyond presence and absence when examining changes in species distributions." *Global Change Biology*.
- Atkinson, A., Hill, S.L., Pakhomov, E.A., Siegel, V., Anadon, R., Chiba, S., Daly, K.L., Downie, R., Fielding, S., Fretwell, P., Gemish, L., Hosie, G.W., Jessopp, M.J., Kawaguchi, S., Krafft, B.A., Loeb, V., Nishikawa, J., Peat, H.J., Reiss, C.S., Ross, R.M., Que tin, L.B., Schmid t, K., Ste inberg, D.K., Subramaniam, R.C., Tarding, G.A. and Ward, P. (2017). "KRILLBASE: A circumpolar database of Antarctic krill and salp numerical densities, 1926-2016." *Earth System Science Data* 9(1): 193-210.
- Bakker, D.C.E., Pfeil, B., Land a, C.S., Metz l, N., O'Brien, K.M., Olsen, A., Smith, K., Cosca, C.,

- Harasawa, S., Jones, S.D., Nakaoaka, S.I., Nojiri, Y., Schuster, U., Steinhoff, T., Sweeney, C., Takahashi, T., Tilbrook, B., Wada, C., Wanninkhof, R., Alin, S.R., Balestrini, C.F., Barbero, L., Bates, N.R., Bianchi, A.A., Boon, F., Boutin, J., Bozec, Y., Burger, E.F., Cai, W.J., Castle, R.D., Chen, L., Chierici, M., Currie, K., Evans, W., Feathestone, C., Feely, R.A., Fransson, A., Goyet, C., Greenwood, N., Gregor, L., Hankin, S., Hardman-Mountford, N.J., Harlay, J., Huck, J., Hoppema, M., Humphreys, M.P., Hunt, C.W., Huss, B., Ibanez, J.S.P., Johannessen, T., Keeling, R., Kitidis, V., Körtzinger, A., Közyr, A., Kraak, P., Kuwata, A., Landschützer, P., Lavett, S.K., Leferre, N., Lo Monaco, C., Manke, A., Mathis, J.T., Merivat, L., Miller, F.J., Monteiro, P.M.S., Munro, D.R., Murata, A., Newberger, T., Omar, A.M., Ono, T., Paterson, K., Pearce, D., Pierrot, D., Robbins, L.L., Saito, S., Salisbury, J., Schlitzer, R., Schneider, B., Schweitzer, R., Sieger, R., Skjellvan, I., Sullivan, K.F., Sutherland, S.C., Sutton, A.J., Tadoke, K., Tszewski, M., Tuma, M., Van Heuven, S.M.A.C., Vandemark, D., Ward, B., Watson, A.J. and Xu, S. (2016). "A multi-decade record of high-quality fCO₂ data in version 3 of the Surface Ocean CO₂ Atlas (SOCAT)." *Earth System Science Data* 8(2): 383-413.
- Bender, M.L., Tilbrook, B., Cassar, N., Johnson, B., Poisson, A. and Trull, T.W. (2016). "Ocean productivity south of Australia during spring and summer." *Deep Sea Research Part I: Oceanographic Research Papers* 112: 68-78.
- Bestley, S., Jonson, I., Harcourt, R.G., Hindell, M.A. and Gales, N.J. (2016). "Putting the behavior into animal movement modeling: Improved activity budgets from use of ancillary tag information." *Ecology and Evolution* 6(22): 8243-8255.
- Bigot, M., Curran, A.J.M., Moy, A.D., Muir, D.C.G., Hawker, D.W., Cropp, R., Teixeira, C.F. and Nash, S.M.B. (2016). "Brief communication: Organochlorine pesticides in an archived firm core from Law Dome, East Antarctica." *Cryosphere* 10(5): 2533-2539.
- Bindoff, N.L. and Hobbs, W.R. (2016). "Southern Ocean: Sea-ice-driven shallow overturning." *Nature Geoscience* 9(8): 569-570.
- Blanchard, J.L., Heneghan, R.F., Everett, J.D., Tebbel, R. and Richardson, A.J. (2017). "From Bacteria to Whales: Using Functional Size Spectra to Model Marine Ecosystems." *Trends in Ecology and Evolution*.
- Boyd, P.W. and Bressan, M. (2016). "Developing a test-bed for robust research governance of geoengineering: the contribution of ocean iron biogeochemistry." *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences* 374(2081).
- Boyd, P.W., Ellwood, M.J., Tagliabue, A. and Twining, B.S. (2017). "Biotic and abiotic retention, recycling and remineralization of metals in the ocean." *Nature Geoscience* 10(3): 167-173.
- Charrette, M.A., Lam, P.J., Lohan, M.C., Kwon, E.Y., Haje, V., Jandel, C., Shiller, A.M., Cutter, G.A., Thomas, A., Boyd, P.W., Homoky, W.B., Milne, A., Thomas, H., Andersson, P.S., Porcelli, D., Tanaka, T., Geibert, W., Dehairs, F. and Garcia-Orellana, J. (2016). "Coastal ocean and shelf-sea biogeochemical cycling of trace elements and isotopes: lessons learned from GEO TRACES." *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences* 374(2081).
- Cimoli, E., Lucier, A., Meiners, K.M., Lund-Hansen, L.C., Kennedy, F., Martin, A., McMin, A. and Lucier, V. (2017). "Towards improved estimates of sea-ice algal biomass: experimental assessment of hyperspectral imaging cameras for under-ice studies." *Annals of Glaciology*: 1-10.
- Clarke, L.J., Beard, J.M., Swadling, K.M. and Deagle, B.E. (2017). "Effect of marker choice and the malcycling protocol on zooplankton DNA metabarcoding studies." *Ecology and Evolution* 7(3): 873-883.
- Clausius, E., McMahon, C.R. and Hindell, M.A. (2017). "Five decades on: Use of historical weaning size data reveals that a decrease in maternal foraging success underpins the long-term decline in population of southern elephant seals (*Mironga leonina*)." *PLoS ONE* 12(3).
- Czechowski, P., Clarke, L.J., Cooper, A. and Stevens, M.I. (2017). "A primer to metabarcoding surveys of Antarctic terrestrial biodiversity." *Antarctic Science* 29(1): 3-15.
- Czechowski, P., White, D., Clarke, L., McKay, A., Cooper, A. and Stevens, M.I. (2016). "Age-related environmental gradients influence invertebrate distribution in the Prince

- Charles Mountains, East Antarctica." *Royal Society Open Science* 3(12).
- Damm, E., Nomura, D., Martin, A., Dieckmann, G.S. and Meiners, K.M. (2016). "DMSP and DMS cycling within Antarctic sea ice during the winter–spring transition." *Deep Sea Research Part II: Topical Studies in Oceanography* 131: 150-159.
- Davidson, A.T., McKinlay, J., Westwood, K., Thomson, P.G., van den Enden, R., de Salas, M., Wright, S., Johnson, R. and Berry, K. (2016). "Enhanced CO₂ concentrations change the structure of Antarctic marine microbial communities." *Marine Ecology Progress Series* 552: 93-113.
- Dinniman, M.S., Asay-Davis, X.S., Galton-Fenzi, B.K., Holland, P.R., Jenkins, A. and Timmermann, R. (2016). "Modeling ice shelf/ocean interaction in Antarctica: A review." *Oceanography* 29(4): 144-153.
- Downes, S.M., Hogg, A.M., Griffies, S.M. and Samuels, B.L. (2016). "The Transient Response of Southern Ocean Circulation to Geothermal Heating in a Global Climate Model." *Journal of Climate* 29(16): 5689-5708.
- Ellis, A., Edwards, R., Saunders, M., Chakrabarty, R.K., Subramanian, R., Timms, N.E., van Riessen, A., Smith, A.M., Lambrinidis, D., Nunes, L.J., Vallelonga, P., Goodwin, I.D., Moy, A.D., Curran, M.A.J. and van Ommen, T.D. (2016). "Individual particle morphology, coatings, and impurities of black carbon aerosols in Antarctic ice and tropical rainfall." *Geophysical Research Letters* 43(22): 11,875-811,883.
- Everett, J.D., Baird, M.E., Buchanan, P., Bulman, C., Davies, C., Downie, R., Griffiths, C., Heghanan, R., Kloser, R.J., Laio, L., Lara-Lopez, A., Lozano-Montes, H., Matear, R.J., McEnulty, F., Robson, B., Rochester, W., Skelett, J., Smith, J.A., Strzelecki, J., Suthers, I.M., Swadling, K.M., van Ruth, P. and Richardson, A.J. (2017). "Modeling What We Sample and Sampling What We Model: Challenges for Zooplankton Model Assessment." *Frontiers in Marine Science* 4(77).
- Farias, D.R., Hurd, C.L., Erikson, R.S., Simioni, C., Schmidt, E., Bozou, Z.L. and Macleod, C.K. (2017). "In situ assessment of *Ulva australis* as a monitoring and management tool for metal pollution." *Journal of Applied Phycology*: 1-14.
- Fernández, P.A., Roldán, M.Y., Leal, P.P. and Hurd, C.L. (2017). "Sea water pH, and not inorganic nitrogen source, affects pH at the blade surface of *Macrocystis pyrifera*: implications for responses of the giant kelp to future oceanic conditions." *Physiologia Plantarum* 159(1): 107-119.
- Fogwill, C.J., Tumeay, C.S.M., Gollidge, N.R., Etheridge, D.M., Rubino, M., Thomton, D.P., Baker, A., Woodward, J., Winter, K., van Ommen, T.D., Moy, A.D., Curran, M.A.J., Davies, S.M., Weber, M.E., Bird, M.I., Munksgaard, N.C., Menviel, L., Rotes, C.M., Ellis, B., Millman, H., Vohra, J., Rivera, A. and Cooper, A. (2017). "Antarctic ice sheet discharge driven by a troposphere-ocean feedbacks at the Last Glacial Termination." *Scientific Reports* 7: 39979.
- Fogwill, C.J., van Sebille, E., Cougnon, E.A., Tumeay, C.S.M., Rintoul, S.R., Galton-Fenzi, B.K., Clark, G.F., Marzine, E.M., Rainsley, E.B. and Carter, L. (2016). "Brief communication: Impacts of a developing polynya off Commonwealth Bay, East Antarctica, triggered by grounding of ice berg B09B." *The Cryosphere* 10(6): 2603-2609.
- Foqrue, M., Beier, S., Jongmans, E., Hunter, R. and Obersteiner, I. (2016). "Uptake of leucine, chitin, and iron by prokaryotic groups during spring phytoplankton blooms induced by natural iron fertilization off Kerguelen Island (Southern Ocean)." *Frontiers in Marine Science* 3(DEC).
- Fripiat, F., Meiners, K.M., Vancoppenolle, M., Papadimitriou, S., Thomas, D.N., Ackley, S.F., Anigo, K.R., Cama, G., Cozzi, S., DeLille, B., Dieckmann, G.S., Dunbar, R.B., Fransso, A., Kattner, G., Kennedy, H., Lannuzel, D., Munro, D.R., Nomura, D., Rintala, J.M., Schoemann, V., Stefels, J., Steiner, N. and Tison, J.L. (2017). "Macro-nutrient concentrations in Antarctic pack ice: Overall patterns and overlooked processes." *Elementa* 5.
- Furue, R., Gueireiro, K., Phillips, H.E., McCreary, J.P. and Bindoff, N.L. (2017). "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(3): 583-602.
- Gan, I., Drewry, D., Allison, I. and Kolyakov, V. (2016). "Science and exploration in the high

- interior of East Antarctica in the twentieth century." *Advances in Polar Science* 27(2): 1-13.
- Gastauer, S., Scoulding, B. and Parsons, M. (2017). "Estimates of variability of goldband snapper target strength and biomass in three fishing regions within the Northern Demersal Scale fish Fishery (Western Australia)." *Fisheries Research* 193: 250-262.
- Giles, A.B. (2017). "The Mertz Glacier Tongue, East Antarctica. Changes in the past 100 years and its cyclic nature - Past, present and future." *Remote Sensing of Environment* 191: 30-37.
- Goedegebuure, M., Melbourne-Thomas, J., Comey, S.P., Hindell, M.A. and Constable, A.J. (2017). "Beyond big fish: The case for more detailed representations of top predators in marine ecosystem models." *Ecological Modelling* 359: 182-192.
- Gong, Y., Zwinger, T., Comford, S., Gladstone, R., SchÄFer, M. and Moore, J.C. (2016). "Importance of basal boundary conditions in transient simulations: case study of a surging marine-terminating glacier on Austfonna, Svalbard." *Journal of Glaciology* 63(237): 106-117.
- Graham, F.S., Morlighem, M., Warner, R.C. and Treverow, A. (2017). "Implementing an empirical scale-invariant anisotropic rheology (ESTAR) into large-scale ice sheet models." *The Cryosphere Discuss.* 2017: 1-26.
- Graham, F.S., Roberts, J.L., Galton-Fenzi, B.K., Young, D., Blankenship, D. and Siegert, M.J. (2017). "A high-resolution synthetic bed elevation grid of the Antarctic continent." *Earth Syst. Sci. Data* 9(1): 267-279.
- Greene, C.A., Gwyther, D.E. and Blankenship, D.D. (2017). "Antarctic Mapping Tools for MATLAB." *Computers and Geosciences* 104: 151-157.
- Groeskamp, S., Lenton, A., Matear, R., Sloyan, B.M. and Langlais, C. (2016). "Anthropogenic carbon in the ocean—Surface to interior connections." *Global Biogeochemical Cycles* 30(11): 1682-1698.
- Grytsai, A., Klekociuk, A., Milinevsky, G., Evtushevsky, O. and Stone, K. (2017). "Evolution of the eastward shift in the quasi-stationary minimum of the Antarctic total ozone column." *Atmos. Chem. Phys.* 17(3): 1741-1758.
- Gwyther, D.E., Cougnon, E.A., Galton-Fenzi, B.K., Roberts, J.L., Hunter, J.R. and Dinniman, M.S. (2016). "Modelling the response of ice shelf basal melting to different ocean cavity environmental regimes." *Annals of Glaciology* 57(73): 131-141.
- Heil, P., Stammejohrn, S., Reid, P., Massom, R.A. and Hutchings, J.K. (2016). "SIPEX 2012: Extreme sea-ice and atmospheric conditions off East Antarctica." *Deep Sea Research Part II: Topical Studies in Oceanography* 131: 7-21.
- Heller, M.L., Wuttig, K. and Croot, P.L. (2016). "Identifying the Sources and Sinks of CDOM/FDOM across the Mauritanian Shelf and Their Potential Role in the Decomposition of Superoxide (O₂-)." *Frontiers in Marine Science* 3(132).
- Hernandez-Boeguer, L., Church, J.A., Allison, I., Peña-Molino, B., Coleman, R., Tomczak, M. and Craven, M. (2016). "Basal melt, seasonal water mass transformation, ocean current variability, and deep convection processes along the Amery Ice Shelf calving front, East Antarctica." *Journal of Geophysical Research: Oceans* 121(7): 4946-4965.
- Hernandez-Boeguer, L., Lannuzel, D., van der Merwe, P., Treverow, A. and Pedro, J.B. (2016). "Large flux of iron from the Amery Ice Shelf marine ice to Prydz Bay, East Antarctica." *Journal of Geophysical Research: Oceans* 121(8): 6009-6020.
- Hindell, M.A., Sumner, M., Bestley, S., Wotherspoon, S., Harcourt, R.G., Lea, M.A., Alderman, R. and McMahon, C.R. (2017). "Decadal changes in habitat characteristics influence population trajectories of southern elephant seals." *Glob Chang Biol*.
- Hobbs, W., Curran, M., Abram, N. and Thomas, E.R. (2016). "Century-scale perspectives on observed and simulated Southern Ocean sea ice trends from proxy reconstructions." *Journal of Geophysical Research: Oceans* 121(10): 7804-7818.
- Hobbs, W.R., Massom, R., Stammejohrn, S., Reid, P., Williams, G. and Meier, W. (2016). "A review of recent changes in Southern Ocean sea ice, their drivers and forcings." *Global and Planetary Change* 143: 228-250.
- Hodgson-Johnston, I., Jackson, A., Jabour, J. and Press, A. (2017). "Cleaning up after human activity in Antarctica: legal obligations and remediation realities." *Restoration Ecology*

- 25(1): 135-139.
- Hogg, A.M., Spence, P., Saenko, O.A. and Downes, S.M. (2017). "The Energetics of Southern Ocean Upwelling." *Journal of Physical Oceanography* 47(1): 135-153.
- Hui, F., Zhao, T., Li, X., Shokr, M., Heil, P., Zhao, J., Zhang, L. and Cheng, X. (2017). "Satellite-based sea ice navigation for Prydz Bay, East Antarctica." *Remote Sensing* 9(6).
- Hutchins, D.A. and Boyd, P.W. (2016). "Marine phytoplankton and the changing ocean iron cycle." *Nature Clim. Change* 6(12): 1072-1079.
- Inoue, M., Curran, M.A.J., Moy, A.D., van Ommen, T.D., Fraser, A.D., Phillips, H.E. and Goodwin, I.D. (2016). "A glaciochemical study of 120 ice core from Mill Island, East Antarctica." *Clim. Past Discuss.* 2016: 1-40.
- Janssens, J., Meiners, K.M., Tison, J.-L., Dieckmann, G., DeLille, B., Lannuzel, D. (2016). "Incorporation of iron and organic matter into young Antarctic sea ice during its initial growth stages." *Elementa - Science of the Anthropocene* 4: 123.
- Jia, Z., Swadling, K.M., Meiners, K.M., Kawaguchi, S. and Virtue, P. (2016). "The zooplankton food web under East Antarctic pack ice – A stable isotope study." *Deep Sea Research Part II: Topical Studies in Oceanography* 131: 189-202.
- Johnson, G.C., Lyman, J.M., Boyer, T., Domingues, C.M., Ishii, M., Killik, R., Monselesan, D. and Wijffels, S.E. (2016). "[Global Oceans] Ocean Heat Content [in 'State of the Climate in 2015']." *Bulletin of American Meteorological Society* 97(8): S66-S70.
- Jones, J.M., Gille, S.T., Gooße, H., Abram, N.J., Canziani, P.O., Charman, D.J., Clem, K.R., Crosta, X., de Lavergne, C., Eisenman, I., England, M.H., Fogt, R.L., Frankcombe, L.M., Marshall, G.J., Marrison-DeMoitte, V., Morrison, A.K., Orsi, A.J., Raphael, M.N., Renwick, J.A., Schneider, D.P., Simpkins, G.R., Steig, E.J., Steenni, B., Swingedouw, D. and Vance, T.R. (2016). "Assessing recent trends in high-latitude Southern Hemisphere surface climate." *Nature Clim. Change* 6(10): 917-926.
- Kelly, P., Clementson, L., Davies, C., Coomey, S. and Swadling, K. (2016). "Zooplankton responses to increasing sea surface temperatures in the south-eastern Australia global marine hotspot." *Estuarine, Coastal and Shelf Science* 180: 242-257.
- Kennicutt, M.C., Kim, Y.D., Rogan-Finnemore, M., Anandakrishnan, S., Chown, S.L., Colwell, S., Cowan, D., Escutia, C., Frenot, Y., Hall, J., Liggett, D., McDonald, A.J., Nixdorf, U., Sieger, M.J., Storey, J., Wåhlin, A., Weatherwax, A., Wilson, G.S., Wilson, T., Wooding, R., Ackley, S., Biebow, N., Blankenship, D., Bo, S., Baeseman, J., Cárdenas, C.A., Cassano, J., Danhong, C., Dañobeitia, J., Francis, J., Guldahl, J., Hashida, G., Corbalán, L.J., Klepikov, A., Lee, J., Leppe, M., Lijun, F., López-Martínez, J., Memoli, M., Motoyoshi, Y., Bueno, R.M., Negrete, J., Cárdenes, M.A.O., Silva, M.P., Ramos-García, S., Sala, H., Shin, H., Shijie, X., Shirashi, K., Stokings, T., Trotter, S., Vaughan, D.G., DeMenese, J.V.D.U., Vlasich, V., Wejia, Q., Winther, J.G., Miller, H., Rintoul, S. and Yang, H. (2016). "Delivering 21st century Antarctic and Southern Ocean science." *Antarctic Science* 28(6): 407-423.
- Kilada, R., Reiss, C.S., Kawaguchi, S., King, R.A., Matsuda, T. and Ichii, T. (2017). "Validation of band counts in eye stalks for the determination of age of Antarctic krill, *Euphausia superba*." *PLoS ONE* 12(2).
- Kohout, A.L., Williams, M.J.M., Toyota, T., Lieser, J. and Hutchings, J. (2016). "In situ observations of wave-induced sea ice breakup." *Deep Sea Research Part II: Topical Studies in Oceanography* 131: 22-27.
- Kusahara, K., Hsumi, H., Fraser, A.D., Aoki, S., Shimada, K., Williams, G.D., Mansom, R. and Tamura, T. (2017). "Modeling ocean-cryosphere interactions off Adélie and George V Land, East Antarctica." *Journal of Climate* 30(1): 163-188.
- Laborusse, S., Salleé, J.B., Fraser, A.D., Mansom, R.A., Reid, P., Hobbs, W., Guinet, C., Harcourt, R., McMahon, C., Authier, M., Bailleul, F., Hindell, M.A. and Charassin, J.B. (2017). "Variability in sea ice cover and climate elicited sex specific responses in an Antarctic predator." *Scientific Reports* 7.
- Laborusse, S., Salleé, J.-B., Fraser, A.D., Mansom, R.A., Reid, P., Sumner, M., Guinet, C., Harcourt, R., McMahon, C., Bailleul, F., Hindell, M.A. and Charassin, J.-B. (2017). "Under the sea ice: Exploring the relationship between sea ice and the foraging behaviour of southern elephant seals in East Antarctica." *Progress in Oceanography*

156: 17-40.

- La nnuzel, D., Che ver, F., van der Merwe, P.C., Jan ssens, J., Ro uka erts, A., Cav agna, A.-J., To wnse nd, A.T, Bow ie, A.R and Me iners, K.M. (2016). "Iro n bio geo che mistry in Anta rctic pack ice during SIPEX-2." *Deep Sea Research Part II: Topical Studies in Oceanography* 131: 111-122.
- La nnuzel, D., Vanc oppenolle, M., Van Der Merwe, P., De Jong, J., Me iners, K.M., Gro tti, M., Nishio ka, J. and Scho emann, V. (2016). "Iro n in sea ice: Re vie w & ne w insights." *Elementa* 4.
- Le Qué ré, C., And re w, R.M., Cana dell, J.G., Sitc h, S., Ko rsba kken, J.I, Pe te rs, G.P., Ma nning, A.C., Bod en, T.A., Ta ns, P.P., Ho ughton, R.A., Ke e ling, R.F., Alin, S., And re ws, O.D., Anthoni, P., Ba be ro, L, Bopp, L, Che vallier, F., Chini, L.P., Cia is, P., Curie, K, De lire, C., Do ney, S.C., Frie dling stein, P., Gkritza lis, T, Hamis, I, Ha uc k, J., Ha ve rd, V., Ho ppe ma, M., Kle in Gold ewijk, K, Jain, A.K, Ka to, E, Kö rtzing er, A., Land sc hütze r, P., Le fè vre, N., Le nto n, A., Lie ne rt, S., Lo mb ardo zzi, D., Me lton, J.R, Me tzl, N., Mille ro, F., Mo nte iro, P.M.S., Munro, D.R., Nabel, J.E.M.S., Na ka o ka, S.I, O'Brie n, K, Olse n, A., Omar, A.M., Ono, T, Pie rot, D., Po ulter, B., Rö denbe ck, C., Sa lisbury, J., Sc huster, U., Sc hwinge r, J., Sé fé rian, R., Skje lvan, I, Sto cker, B.D., Sutto n, A.J., Ta ka ha shi, T, Tian, H, Tilb ro ck, B., van der La an-Luijckx, I.T, van der Werf, G.R, Vio vy, N., Walke r, A.P., Wiltshire, A.J. and Za ehle, S. (2016). "Glo bal Carbon Budget 2016." *Earth Syst. Sci. Data* 8(2): 605-649.
- Lee, J.R., Raymo nd, B., Bra ce girdle, T.J., Cha dè s, I., Fuller, R.A., Sha w, J.D. and Te ra uds, A. (2017). "Clima te change drives expan sion of Anta rctic ice-free habita t." *Nature* 547(7661): 49-54.
- Lee, L.C., Watso n, J.C., Te bilco, R. and Sa lomon, A.K (2016). "Indire ct effects and prey be ha vior me dia te inte rac tions be twee n an endangere d prey and re co ve ring pre da to r." *Ecosphe re* 7(12).
- Lei, R., Tian-Kunze, X., Li, B., He il, P., Wang, J., Ze ng, J. and Tian, Z. (2017). "Cha ra cte riza tion of summer Arc tic sea ice mo rpho logy in the 135°–175°W sec to r using multi-sca le me tho ds." *Cold Regions Science and Tech no logy* 133: 108-120.
- Le ma itre, N., Plan que tte, H., De hairs, F., van der Merwe, P., Bow ie, A.R., Trull, T.W., La ure nca u-Come c, E.C., Davie s, D., Bollinger, C., Le Goff, M., Gros ste ffa n, E. and Plan chon, F. (2016). "Impa ct of the natu ral Fe-fe rtiliza tion on the mag nitude, sto ichio me try and effi cie ncy of partic ula te bio ge nic silica, nitro ge n and iro n ex port fluxes." *Deep-Sea Research Part I: Oceanographic Research Papers* 117: 11-27.
- Le nto n, A., Keller, D. and Pfiste r, P. (2017). "Ho w will Earth re spond to plans fo r carbon dio xide re mo val?," *Eos* 98.
- Linge n, B., Alliso n, I., Cunde, X., Yong fe ng, M., Liang, F. and Ming hu, D. (2016). "Clima te and me te o ro lo gi cal pro ce sses of the Ea st Anta rctic ice she et be twee n Zhongshan and Do me -A." *Advances in Polar Science* 27(2): 90-101.
- Ma ka be, R., Ta nimura, A., Ta mura, T., Hira no, D., Shimada, K., Ha shi ha ma, F. and Fukuc hi, M. (2017). "Me so-zo opla nkto n abun da nce and spa tial di stribu tion off Lü tzo w-Ho lm Bay du ring austra l summe r 2007–2008." *Polar Science* 12: 25-33.
- Ma r us, L., Virtue, P., Nic hols, P.D., Me e ka n, M.G. and Pe thyb ridge, H. (2017). "Effe cts of sa mple tre a tme nt on the ana lysis of sta ble iso to pes of ca rbon and nitro ge n in zo opla nkto n, mic ro ne kto n and a filte r-fe e ding sha rk." *Marine Biology* 164(6).
- Ma r us, L., Virtue, P., Nic hols, P.D., Me e ka n, M.G. and Pe thyb ridge, H. (2017). "Effe cts of sa mple tre a tme nt on the ana lysis of sta ble iso to pes of ca rbon and nitro ge n in zo opla nkto n, mic ro ne kto n and a filte r-fe e ding sha rk." *Marine Biology* 164(6): 124.
- Ma ri ta ti, A., Aitke n, A.R.A., Yo ung, D.A., Ro be rts, J.L, Blan kenship, D.D. and Sie ge rt, M.J. (2016). "The tec to nic de ve lo pme nt and ero sion of the Kno x Sub gla cial Se di me nta ry Ba sin, Ea st Anta rctic a." *Geophysic al Research Lette rs* 43(20): 10,728-710,737.
- Ma rzlo ff, M.P., Me lbou me-Tho mas, J., Ha mo n, K.G., Ho shino, E., Je nning s, S., van Putte n, I.E. and Pe c l, G.T (2016). "Mo de lling ma rine co m mu nity re sponse s to clima te-dri ve n spe cie s re di stribu tion to guide mo ni to ring and ada pti ve eco syste m-ba sed ma na ge me nt." *Global Change Biology* 22(7): 2462-2474.
- Ma rzlo ff, M.P., Me lbou me-Tho mas, J., Ha mo n, K.G., Ho shino, E., Je nning s, S., Van Putte n, I.E. and Pe c l, G.T (2017). "Co rri ge ndum to: Mo de lling ma rine co m mu nity re sponse s to

- climate-driven species redistribution to guide monitoring and adaptive ecosystem-based management (*Global Change Biology*, (2016), 22, 7, (2462-2474), 10.1111/gcb.13285)." *Global Change Biology* 23(3): 1360.
- Mayewski, P.A., Carleton, A.M., Birkel, S.D., Dixon, D., Kurbatov, A.V., Korotkikh, E., McConnell, J., Curran, M., Cole-Dai, J., Jiang, S., Plummer, C., Vance, T., Maasch, K.A., Sneed, S.B. and Handley, M. (2017). "Ice core and climate reanalysis analogs to predict Antarctic and Southern Hemisphere climate changes." *Quaternary Science Reviews* 155: 50-66.
- McCaulley, R., Day, R., Swadling, K., Fitzgibbon, Q., Watson, R. and Semmens, J. (2017). "Widely used marine seismic survey airgun operations negatively impact zooplankton." *Nature Ecology & Evolution* 1(Article 0195).
- McMahon, C.R., Harcourt, R.G., Burton, H.R., Daniel, O. and Hindell, M.A. (2017). "Seal mothers expend more on offspring under favorable conditions and less when resources are limited." *Journal of Animal Ecology* 86(2): 359-370.
- Meiners, K.M., Golden, K.M., Heil, P., Lieser, J.L., Massom, R., Meyer, B. and Williams, G.D. (2016). "Introduction: SIPEX-2: A study of sea-ice physical, biogeochemical and ecosystem processes off East Antarctica during spring 2012." *Deep Sea Research Part II: Topical Studies in Oceanography* 131: 1-6.
- Melbourn-Thomas, J., Constable, A.J., Fulton, E.A., Comey, S.P., Thebilo, R., Hobday, A.J., Blanchard, J.L., Boschetti, F., Bustamante, R.H., Cropp, R., Everett, J.D., Fleming, A., Galton-Fenzi, B., Goldsworthy, S.D., Lenton, A., Lara-Lopez, A., Little, R., Marzloff, M.P., Matear, R., Mongin, M., Plagányi, E., Proctor, R., Risbey, J.S., Robson, B.J., Smith, D.C., Sumner, M.D. and van Putten, I.E. (2017). "Integrated modelling to support decision-making for marine social-ecological systems in Australia." *ICES Journal of Marine Science* fsx078: 1-11.
- Melbourn-Thomas, J., Comey, S.P., Thebilo, R., Meiners, K.M., Stevens, R.P., Kawaguchi, S., Sumner, M.D. and Constable, A.J. (2016). "Underice habitats for Antarctic krill larvae: Could less mean more under climate warming?" *Geophysical Research Letters* 43(19): 10,322-310,327.
- Michael Gladstone, R., Charles Wamer, R., Keith Galton-Fenzi, B., Gagliardini, O., Zwinger, T. and Greve, R. (2017). "Marine ice sheet model performance depends on basal sliding physics and sub-shelf melting." *Cryosphere* 11(1): 319-329.
- Mori, M., Comey, S.P., Melbourn-Thomas, J., Welsford, D.C., Klocker, A. and Ziegler, P.E. (2016). "Using satellite altimetry to inform hypotheses of transport of early life stage of Patagonian toothfish on the Kerguelen Plateau." *Ecological Modelling* 340: 45-56.
- Moteki, M., Odate, T., Hosie, G.W., Takahashi, K.T., Swadling, K.M. and Tanimura, A. (2017). "Ecosystem studies in the Indian Ocean sector of the Southern Ocean undertaken by the training vessel Umitaka-maru." *Polar Science* 12: 1-4.
- Muller, M.N., Trull, T.W. and Hallegraeff, G.M. (2017). "Independence of nutrient limitation and carbon dioxide impacts on the Southern Ocean coccolithophore *Emiliania huxleyi*." *ISME J*.
- Naughton, K.A., Galton-Fenzi, B.K., Meissner, K.J., England, M.H., Brassington, G.B., Colberg, F., Hattemann, T. and Debernard, J.B. (2017). "Spurious sea ice formation caused by oscillatory ocean tracer advection schemes." *Ocean Modelling* 116(Supplement C): 108-117.
- Obase, T., Abe-Ouchi, A., Kushihara, K., Hasumi, H. and Ohgaito, R. (2017). "Response of basal melting of antarctic ice shelves to the climatic forcing of the last glacial maximum and CO₂ doubling." *Journal of Climate* 30(10): 3473-3497.
- Patterson, T.A., Sharples, R.J., Raymond, B., Welsford, D.C., Andrews-Goff, V., Lea, M.A., Goldsworthy, S.D., Gale, N.J. and Hindell, M. (2016). "Foraging distribution overlap and marine reserve usage amongst sub-Antarctic predators inferred from a multi-species satellite tagging experiment." *Ecological Indicators* 70: 531-544.
- Peña-Molino, B., McCartney, M.S. and Rintoul, S.R. (2016). "Direct observations of the Antarctic Slope Current transport at 113°E." *Journal of Geophysical Research: Oceans* 121(10): 7390-7407.
- Petrou, K., Kranz, S.A., Timbom, S., Hassler, C.S., Ameijeiras, S.B., Sackett, O., Ralph, P.J. and Davidson, A.T. (2016). "Southern Ocean phytoplankton physiology in a changing

- climate." *Journal of Plant Physiology* 203: 135-150.
- Picard, G., Libois, Q. and Arnaud, L. (2016). "Refinement of the ice absorption spectrum in the visible using radiance profile measurements in Antarctic snow." *The Cryosphere* 10(6): 2655-2672.
- Pittard, M.L, Galton-Fenzi, B.K, Roberts, J.L and Watson, C.S. (2016). "Organization of ice flow by localized regions of elevated geothermal heat flux." *Geophysical Research Letters* 43: 3342-3350.
- Pittard, M.L, Roberts, J.L, Galton-Fenzi, B.K and Watson, C.S. (2016). "Sensitivity of the Lambert-Amery glacial system to geothermal heat flux." *Annals of Glaciology* 57(73): 56-68.
- Post, A.L, La voie, C., Domack, E.W., Leventer, A., Shevener, A. and Fraser, A.D. (2017). "Environmental drivers of benthic communities and habitat heterogeneity on an East Antarctic shelf." *Antarctic Science* 29(1): 17-32.
- Proemse, B.C., Murray, A.E, Schallenberg, C., McKernan, B, Glazer, B.T, Young, S.A., Ostrom, N.E, Bowie, A.R., Wieser, M.E, Kenig, F., Doran, P.T and Edwards, R. (2017). "Iron cycling in the anoxic cryo-ecosystem of Antarctic Lake Vida." *Biogeochemistry*: 1-11.
- Ramm, T.D., White, C.J., Chan, A.H.C. and Watson, C.S. (2017). "A review of methodologies applied in Australian practice to evaluate long-term coastal adaptation options." *Climate Risk Management* 17(Supplement C): 35-51.
- Ratnarajah, L and Bowie, Andrew R. (2016). "Nutrient Cycling: Are Antarctic Krill a Previously Overlooked Source in the Marine Iron Cycle?" *Current Biology* 26(19): R884-R887.
- Ratnarajah, L, Lannuzel, D., Townsend, A.T, Meiners, K.M., Nicol, S., Friedlander, A.S. and Bowie, A.R. (2017). "Physical speciation and solubility of iron from baleen whale faecal material." *Marine Chemistry* 194(Supplement C): 79-88.
- Reid, P., Mansom, R.A., Stammerjohn, S., Barreria, S., Lieser, J.L and Scambos, T. (2016). "[Antarctic a] Sea ice extent, concentration, and duration [in 'State of the Climate in 2015']." *Bulletin of American Meteorological Society* 97(8): S163-S166.
- Rintoul, S.R., Silva, A., Pena-Molino, B., van Wijk, E., Rosenber, M., Greenbaum, J.S. and Blenkinship, D.D. (2016). "Ocean heat drives rapid basal melt of the Totten Ice Shelf." *Science Advances* 2(12).
- Roberts, J., Curran, M., Poynter, S., Moy, A., Ommen, T.V., Vance, T., Toner, C., Graham, F.S., Young, D.A., Plummer, C., Pedro, J., Blenkinship, D. and Siegert, M. (2017). "Correlation confidence limits for unevenly sampled data." *Computers and Geosciences* 104: 120-124.
- Roden, N.P., Tilbrook, B., Tull, T.W., Virtue, P. and Williams, G.D. (2016). "Carbon cycling dynamics in the seasonal sea-ice zone of East Antarctica." *Journal of Geophysical Research: Oceans* 121(12): 8749-8769.
- Rodriguez, E.S., Nation, M., Moy, A.D., Curran, M.A.J., Haddad, P.R., Nestrenko, P.N. and Paull, B. (2016). "Application of capillary ion chromatography and capillary ion chromatography coupled with mass spectrometry to determine methane sulfonate and inorganic anions in micro liter sample volumes of Antarctic snow and ice." *Analytical Methods* 8(42): 7650-7660.
- Roukerts, A., Cavagna, A.-J., Fripjat, F., Lannuzel, D., Meiners, K.M. and Dehairs, F. (2016). "Sea-ice algal primary production and nitrogen uptake rates off East Antarctica." *Deep Sea Research Part II: Topical Studies in Oceanography* 131: 140-149.
- Salle, J.B., Mazloff, M., Meredith, M.P., Hughes, C.W., Rintoul, S., Gomez, R., Metz, N., Lo Monaco, C., Schmidtko, S., Mata, M.M., Wahlin, A., Swart, S., Williams, M.J.M., Naveira-Garabata, A.C. and Monteiro, P. (2016). "[Antarctic a] Southern Ocean [in 'State of the Climate in 2015']." *Bulletin of American Meteorological Society* 97(8): S166-S168.
- Schallenberg, C., Ross, A.R.S., Davidson, A.B., Stewart, G.M. and Cullen, J.T. (2017). "Temporal variability of dissolved iron species in the mesopelagic zone at Ocean Station PAPA." *Journal of Marine Systems* 172: 128-136.
- Schallenberg, C., van der Merwe, P., Chaver, F., Cullen, J.T., Lannuzel, D. and Bowie, A.R. (2016). "Dissolved iron and iron(II) distributions beneath the pack ice in the East Antarctic (120°E) during the winter/spring transition." *Deep Sea Research Part II*

- Topical Studies in Oceanography 131: 96-110.
- Schofield, O., Newman, L., Bricher, P., Constable, A., Swart, S. and Wåhlin, A. (2016). "Moving Towards Implementation of a Southern Ocean Observing System." *Marine Technology Society Journal* 50(3): 63-68.
- Schoz, F., Löschner, C.R., Fiskal, A., Sommer, S., Henzen, C., Lomnitz, U., Wuttig, K., Göttlicher, J., Kossel, E., Steining, R. and Canfield, D.E. (2016). "Nitrate-dependent iron oxidation limits iron transport in anoxic ocean regions." *Earth and Planetary Science Letters* 454: 272-281.
- Schroeter, S., Hobbs, W. and Bindoff, N.L. (2017). "Interactions between Antarctic sea ice and large-scale atmospheric modes in CMIP5 models." *The Cryosphere* 11(2): 789-803.
- Silvano, A., Rintoul, S.R. and Herraiz-Bohreguerro, L. (2016). "Ocean-ice shelf interaction in East Antarctica." *Oceanography* 29(4): 130-143.
- Silvano, A., Rintoul, S.R., Peña-Molino, B. and Williams, G.D. (2017). "Distribution of water masses and meltwater on the continental shelf near the Totten and Moscow University ice shelves." *Journal of Geophysical Research: Oceans*.
- Singh, H., Maksym, T., Wilkinson, J. and Williams, G. (2017). "Inexpensive, small AUVs for studying ice-covered polar environments." *Science Robotics* 2(7).
- Sinoir, M., Bowie, A.R., Mongin, A., Butler, E.C.V. and Hassler, C.S. (2017). "Zinc requirement for two phytoplankton strains of the Tasman Sea." *Marine and Freshwater Research* 68(2): 361-372.
- Slangen, A., van de Wal, R., Reerink, T., de Winter, R., Hunter, J., Woodworth, P. and Edwards, T. (2017). "The Impact of Uncertainties in Ice Sheet Dynamics on Sea-Level Allowances at Tide Gauge Locations." *Journal of Marine Science and Engineering* 5(2): 21.
- Snow, K., Sloyan, B.M., Rintoul, S.R., Hogg, A.M. and Downes, S.M. (2016). "Controls on circulation, cross-shelf exchange, and dense water formation in an Antarctic polynya." *Geophysical Research Letters* 43(13): 7089-7096.
- Steer, A., Heil, P., Watson, C., Mansom, R.A., Lieser, J.L. and Ozsoy-Cicek, B. (2016). "Estimating small-scale snow depth and ice thickness from total freeboard for East Antarctic sea ice." *Deep Sea Research Part II: Topical Studies in Oceanography* 131: 41-52.
- Subramaniam, R.C., Melbourne-Thomas, J., Davidson, A.T. and Comey, S.P. (2017). "Mechanisms driving Antarctic microbial community responses to ocean acidification: a network modelling approach." *Polar Biology* 40(3): 727-734.
- Sukhodolov, T., Usoskin, I., Rozanov, E., Asvestari, E., Ball, W.T., Curran, M.A.J., Fischer, H., Kovaltsov, G., Miyake, F., Peter, T., Plummer, C., Schmutz, W., Severi, M. and Traversi, R. (2017). "Atmospheric impacts of the strongest known solar particle storm of 775 AD." *Scientific Reports* 7.
- Sun, S., Comford, S.L., Gwyther, D.E., Gladstone, R.M., Galton-Fenzi, B.K., Zhao, L. and Moore, J.C. (2016). "Impact of ocean forcing on the Aurora Basin in the 21st and 22nd centuries." *Annals of Glaciology* 57(73): 79-86.
- Tagliabue, A., Bowie, A.R., Boyd, P.W., Buck, K.N., Johnson, K.S. and Saito, M.A. (2017). "The integral role of iron in ocean biogeochemistry." *Nature* 543(7643): 51-59.
- Thomson, P.G., Davidson, A.T. and Maher, L. (2016). "Increasing CO₂ changes community composition of pico- and nano-sized protists and prokaryotes at a coastal Antarctic site." *Marine Ecology Progress Series* 554: 51-69.
- Toyota, T., Kohout, A. and Fraser, A.D. (2016). "Formation processes of sea ice floe size distribution in the interior pack and its relationship to the marginal ice zone off East Antarctica." *Deep Sea Research Part II: Topical Studies in Oceanography* 131: 28-40.
- Toyota, T., Mansom, R., Lecomte, O., Nomura, D., Heil, P., Tamura, T. and Fraser, A.D. (2016). "On the extraordinary snow on the sea ice off East Antarctica in late winter, 2012." *Deep Sea Research Part II: Topical Studies in Oceanography* 131: 53-67.
- Tozer, C.R. and Kiem, A.S. (2017). "Large-scale ocean-atmospheric processes and seasonal rainfall variability in South Australia: accounting for non-linearity and establishing the hierarchy of influence." *International Journal of Climatology* 37: 1180-1198.
- Tozer, C.R., Kiem, A.S. and Verdun-Kidd, D.C. (2017). "Large-scale ocean-atmospheric processes and seasonal rainfall variability in South Australia: potential for improving seasonal hydroclimatic forecasts." *International Journal of Climatology*.

- Ugalde, S.C., Westwood, K.J., van den Enden, R., Mc Minn, A. and Meiners, K.M. (2016). "Characteristics and primary productivity of East Antarctic pack ice during the winter-spring transition." *Deep Sea Research Part II: Topical Studies in Oceanography* 131: 123-139.
- Vallelonga, P., Maffezzo, N., Moy, A.D., Curran, M.A.J., Vance, T.R., Edwards, R., Hughes, G., Barker, E., Spreen, G., Saiz-Lopez, A., Corella, J.P., Cuevas, C.A. and Spolaor, A. (2017). "Sea-ice-related halogen enrichment at Law Dome, coastal East Antarctica." *Clim. Past* 13(2): 171-184.
- Vance, T.R., Roberts, J.L., Plummer, C.T., Kiem, A.S. and Van Ommen, T.D. (2017). "Comment on 'Drought variability in the eastern Australia and New Zealand summer drought atlas (ANZDA, CE 1500-2012) modulated by the Interdecadal Pacific Oscillation'." *Environmental Research Letters* 12(6).
- Virtue, P., Meyer, B., Freier, U., Nichols, P.D., Jia, Z., King, R., Virtue, J., Swadling, K.M., Meiners, K.M. and Kawaguchi, S. (2016). "Condition of larval (*furcilia* VI) and one year old juvenile *Euphausia superba* during the winter-spring transition in East Antarctica." *Deep Sea Research Part II: Topical Studies in Oceanography* 131: 182-188.
- Wallis, J.R., Swadling, K.M., Everett, J.D., Suthers, I.M., Jones, H.J., Buchanan, P.J., Crawford, C.M., James, L.C., Johnson, R., Meiners, K.M., Virtue, P., Westwood, K. and Kawaguchi, S. (2016). "Zooplankton abundance and biomass size spectra in the East Antarctic sea-ice zone during the winter-spring transition." *Deep Sea Research Part II: Topical Studies in Oceanography* 131: 170-181.
- Wilks, J.V., Rigual-Hernández, A.S., Trull, T.W., Bray, S.G., Flores, J.-A. and Armand, L.K. (2017). "Biogeochemical flux and phytoplankton succession: A year-long sediment trap record in the Australian sector of the Subantarctic Zone." *Deep Sea Research Part I: Oceanographic Research Papers* 121: 143-159.
- Williams, G.D., Herraiz-Boreguro, L., Roquet, F., Tamura, T., Ohshima, K.I., Fukumachi, Y., Frazer, A.D., Gao, L., Chen, H., McMahon, C.R., Harcourt, R. and Hindell, M. (2016). "The suppression of Antarctic bottom water formation by melting ice shelves in Prydz Bay." *Nature Communications* 7: 12577.
- Williams, S.D.P., Woodworth, P.L. and Hunter, J.R. (2016). "Commentary on 'Coastal Planning Should Be Based on Proven Sea Level Data' by A. Parker and C.D. Ollier (*Ocean & Coastal Management*, 124, 1-9, 2016)." *Journal of Coastal Research* 32(4): 992-997.
- Woodworth, P.L., Hunter, J.R., Marcos, M., Caldwell, P., Menéndez, M. and Haigh, I. (2016). "Towards a global higher-frequency sea level dataset." *Geoscience Data Journal* 3(2): 50-59.
- Zhao, C. and Allison, I. (2016). "Some aspects of Chinese-Australian cooperation in Antarctic Research over the past forty years." *Advances in Polar Science* 27(2): 126-137.

Appendix 2– ACE CRC PhD students 2016-2017

Commenced in 2016/17

Name	Commencement Date	Status	Research Program	Project Title	Research Organisation	Country	Expected Completion Date
1. Abdul Salam, Syed	9/06/2017	FT	Oceans & Cryosphere	The temperature distribution within the East Antarctic Ice Sheet	UTAS	Australia	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	Australia	December 2020
3. Campbell, Sharon	1/03/2017	FT	Climate Futures	Understanding current and future impacts of extreme heat events on the health of vulnerable Tasmanians	UTAS	Australia	September 2020
4. Duprat, Luis	1/08/2016	FT	Carbon & Ecosystems	Role of sea ice as a source of bio-available iron to Antarctic surface waters	UTAS	Australia	March 2020
5. Genovese, Cristina	29/11/2016	FT	Carbon & Ecosystems	Role of organic ligands in the distribution of iron in polar waters	UTAS	Australia	June 2020
6. Hollman, Hannes	1/03/2017	FT	Oceans & Cryosphere	Geophysical investigation of the subglacial environment and its role in the evolution of ice dynamics	UTAS	Australia	September 2020
7. 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

*FT- full-time internal; FX - full-time external; PT- part-time internal; PX - part-time external

Name	Commencement Date	Status	Research Program	Project Title	Research Organisation	Country	Expected Completion Date
8. Rathore, Sa urabh	31/10/2016	FT	Oceans & Cryosphere	The impact of recent Indian Ocean warming on the circulation, water mass distribution and air-sea interaction	UTAS	Australia	May 2020
9. Subramaniam, Ro shni	11/07/2016	FT	Carbon & Ec osystems	Food web modelling for the Indian sector of the Southern Ocean	UTAS	Australia	December 2020

Completed

Name	Commencement Date	Status	Research Program	Project Title	Research Organisation	Country	Expected Completion Date
1. Arthur, Benjamin	31/10/2011	FT	Carbon & Ec osystems	Winter Habitat Usage and Trophic Links for Antarctic Fur Seal Populations in the Southern Ocean	UTAS	Australia	Graduated December 2016
2. Baker, Barry	31/07/2002	PT	Carbon & Ec osystems	Demography and Conservation of Shy Albatross (<i>Thalassarche cauta</i>)	UTAS	Australia	Graduated 2016
3. Cougnon, Eva	08/10/2012	FT	Oceans & Cryosphere	Quantifying the Impact of Glacial Melt Water on Antarctic Bottom Water	UTAS	Australia	Graduated December 2016
4. Della Penna, Alice	19/11/2012	FX	Carbon & Ec osystems	Living in a fluid dynamical system: how do marine predator respond to turbulence?	UTAS	Australia	Graduated August 2016
5. Gwyther, David	05/03/2012	FT	Oceans & Cryosphere	Investigating the Impact of Ocean Warming on Antarctic Ice Shelves	UTAS	Australia	Graduated August 2016

Name	Commencement Date	Status	Research Program	Project Title	Research Organisation	Country	Expected Completion Date
6. Inoue, Mana	04/04/2011	FT	Oceans & Cryosphere	Glacioc hemical Study of Mill Island Ice Core Records	UTAS	Australia	Graduated August 2016
7. Jackson, Christine	15/01/2006	PX	Carbon & Ecosystems	Determining Cetacean - Cephalopod Trophic Interactions - A Qualitative and Quantitative Approach	UTAS	Australia	Graduated December 2016
8. Jia, Zhongnan	02/05/2011	FT	Carbon & Ecosystems	Diet and Energy Budget of Antarctic Krill (<i>Euphausia superba</i>) - Relationship between Krill and Winter Sea Ice	UTAS	Australia	Graduated August 2016
9. Johnson, Rob	07/02/2011	PT	Carbon & Ecosystems	Effects of Climate Change on Phytoplankton Primary Production and Chemo taxonomy in Southern Ocean and Antarctic Ecosystems	UTAS	Australia	Graduated December 2016
10. Pittard, Mark	30/04/2012	FT	Oceans & Cryosphere	Ice Sheet Response to Enhanced Ice Shelf Basal Melt	UTAS	Australia	Graduated December 2016
11. Steer, Adam	01/10/2009	FT	Oceans & Cryosphere	Optimising Airborne LiDAR Positioning for Remote Area Geophysical Surveys	UTAS	Australia	Graduated December 2016
12. Winton, Holly	September 2012	FT	Carbon & Ecosystems	Impact of biomass burning emissions and dust on soluble iron deposition to Australian waters, the Southern Ocean and Antarctica	Curtin University	Australia	Graduated September 2016
13. Younger, Jane	06/06/2011	FT	Carbon & Ecosystems	Glacial Refugia of Antarctic Ice Breeding Species	UTAS	Australia	Graduated December 2016

Continuing

Name	Commencement Date	Status	Research Program	Project Title	Research Organisation	Country	Expected Completion Date
1. Afle nze r, Hele ne	18/04/2016	FT	Carbon & Ec o syste ms	Impact of oce an ac id if ic a tio n on the a va il a b il it y and to x ic it y of tra ce e le me nts and nu tri e nts	UTAS	Austra lia	October 2019
2. Ale xa n de r, Ka itlin	September 2014	FT	O ce a ns & Cryo sp he re	Re s po n se of sub-ic e she lf c ir cu la tio n to 21 st ce n tu ry pr o je c tio ns of c li ma te c ha n ge	Unive rsity of New South Wa le s	Austra lia	September 2018
3. Ba ir d -Bo we r, De bb ie	08/04/2013	FT	Carbon & Ec o syste ms	De mo gra ph ic Re s po n se s of Anta rc tic Fur Se a ls to Enviro n me n ta l Va ri a b il it y	UTAS	Austra lia	April 2017
4. Be d fo rd , Me rel	01/03/2014	FT	Carbon & Ec o syste ms	Re p re se n ti ng So ut he m O ce a n pre da to rs in end-to - end ec o sy ste m mo de ls us ing in di vi du a l-b a se d mo de lli ng	UTAS	Austra lia	September 2017
5. Bla ck, Ja me s	28/08/2014	FT	Carbon & Ec o syste ms	Me a su ri ng im pa cts of oce an ac id if ic a tio n on bio lo gi ca l co m mu ni ti es in Anta rc tic a : an in-situ ex pe ri me nt and la bo ra to ry ex pl o ra tio n of the me c ha ni sm s of co m mu ni ty	UTAS	Austra lia	February 2018
6. Bla n che , Be lla	08/02/2016	FT	O ce a ns & Cryo sp he re	De te c ti ng hu ma n in fl u e n ce in gl ob a l oc e a n sa li ni ty pa tte ms	UTAS	Austra lia	August 2019
7. Buc ha na n, Pe a rse	01/11/2014	FT	O ce a ns & Cryo sp he re	O ce a n De o xy ge na tio n: A pa le o -mo de lli ng pe rs pe c ti ve	UTAS	Austra lia	May 2018
8. Cle e la nd , Ja im ie	20/05/2013	FT	Carbon & Ec o syste ms	Ma c qua ri e Is la nd 's Al ba tro sse s: A co m p re he n si ve as se ss me nt of po pu la tio n and	UTAS	Austra lia	July 2017

Name	Commencement Date	Status	Research Program	Project Title	Research Organisation	Country	Expected Completion Date
				demographic status and trends and the environmental and anthropogenic			
9. Cimoli, Emiliano	31/03/2016	FT	Oceans & Cryosphere	Hyperspectral remote sensing of Antarctic sea ice algae and benthos using AUV	UTAS	Australia	September 2019
10. Cranenburgh, Andrea	01/03/2016	FT	Oceans & Cryosphere	How do standing meanders break the ACC?	UTAS	Australia	September 2019
11. Cyriac, Ajitha	18/11/2015	FT	Oceans & Cryosphere	Eastward flows, ocean mixing and air-sea interaction in the Southeast Indian Ocean	UTAS	Australia	June 2019
12. Deppele, Stacy	15/10/2013	FT	Carbon & Ecosystems	Effects of Elevated pCO ₂ on the Productivity of Marine Microbes and the Remineralisation of Nutrients in Coastal Antarctic Waters	UTAS	Australia	April 2017
13. Dias, Fabio	24/08/2015	FT	Oceans & Cryosphere	Testing of Climate Models and Sea Level Rise Projections using Observations of Ocean Heat Uptake	UTAS	Australia	February 2019
14. Durand, Axel	03/04/2013	FT	Carbon & Ecosystems	Ocean Deoxygenation, a Paleo Proxy Perspective	UTAS	Australia	January 2017
15. Ericson, Jessica	15/10/2015	FT	Carbon & Ecosystems	Using Signature Lipid Analysis to Understand the Biology and Ecology of Antarctic Krill (<i>Euphausia superba</i>)	UTAS	Australia	April 2019
16. 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	Expected Completion Date
17. Freyer, Julien	01/03/2016	FT	Carbon & Ecosystems	Comparative diving physiology and ecology across the Southern Ocean marine predators	UTAS	Australia	September 2019
18. Gamble Rosevear, Madeleine	01/02/2016	FT	Oceans & Cryosphere	Fine scale ocean processes driving the basal melting of ice shelves	UTAS	Australia	August 2019
19. Hancock, Alice	1/1/2016	FT	Carbon & Ecosystems	Effects of ocean acidification on associations among Antarctic and SO marine microbes	UTAS	Australia	July 2019
20. Hamilton, Vicki	24/07/2012	PT	Carbon & Ecosystems	Energetic Variability in Sperm Whales and Relationships with the Marine Environment	UTAS	Australia	December 2017
21. Hellesey, Nicole	01/11/2015	FT	Carbon & Ecosystems	Seasonal lipid changes in Antarctic krill in relation to Climate Change	UTAS	Australia	June 2019
22. 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
23. 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
24. Huneke, Wilma	19/10/2015	FT	Oceans & Cryosphere	Quantifying Key Physical Processes Responsible for Ocean Warming under Antarctic Ice Shelves	UTAS	Australia	January 2019
25. Jackson, Andrew	01/03/2015	FT	Carbon & Ecosystems	Who Saved Antarctica?	UTAS	Australia	September 2018

Name	Commencement Date	Status	Research Program	Project Title	Research Organisation	Country	Expected Completion Date
26. Jansen, Jan	01/10/2014	FT	Carbon & Ecosystems	Modelling biodiversity in the Southern Ocean and Antarctica using sparse data	UTAS	Australia	April 2019
27. Janssens, Julie	06/09/2012	FT	Carbon & Ecosystems	Incorporation Mechanisms of Organic Matter and Iron into Sea Ice	UTAS	Australia	Submitted
28. Kelly, Paige	01/08/2015	FT	Carbon & Ecosystems	Climate Change and Sea Ice Habitats: Modelling effects from plankton to penguins	UTAS	Australia	February 2019
29. Kennedy, Fraser	18/08/2015	FT	Carbon & Ecosystems	Using experimental sea ice tanks and micro sensors to investigate sea ice microbial ecology	UTAS	Australia	February 2019
30. 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 - Coteille	Australia	March 2018
31. Lago, Veronique	06/04/2011	FT	Oceans & Cryosphere	Testing of climate models and sea level rise projections using observations of ocean heat uptake	UTAS	Australia	Submitted September 2015
32. Lee, Shi Hong	15/12/2012	FT	Carbon & Ecosystems	Impact of Climate Change on Physiological and Behavioral Responses of Coastal Microphytobenthos	UTAS	Australia	March 2017
33. Libaros, Damien	28/08/2015	FT	Oceans & Cryosphere	Determining changes in sea level around Antarctica	UTAS	Australia	February 2019
34. McCormack, Stacey	22/07/2015	FT	Carbon & Ecosystems	Energy Flow in Southern Ocean Ecosystems:	UTAS	Australia	January 2019

Name	Commencement Date	Status	Research Program	Project Title	Research Organisation	Country	Expected Completion Date
				Comparing mass balance and size-based approaches			
35. 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	Submitted
36. Mori, Mao	01/12/2014	FT	Carbon & Ecosystems	Modelling ocean transport of key species in the Indian sector of the Southern Ocean	UTAS	Australia	June 2018
37. Patel, Ramkrushn bai	02/03/2016	FT	Oceans & Cryosphere	The physical and bio-optical structure of Southern Ocean eddies in observations and models	UTAS	Australia	September 2019
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 the Sequestration of Circulation, Productivity and Dust Input	UTAS	Australia	January 2019
40. Perron, Morgane	02/05/2016	FT	Carbon & Ecosystems	Natural iron fertilisation of oceans around Australia linking terrestrial aerosols to marine biogeochemistry	UTAS	Australia	November 2019

Name	Commencement Date	Status	Research Program	Project Title	Research Organisation	Country	Expected Completion Date
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	Submitted
42. Polanowski, Andrea	03/10/2011	PT	Carbon & Ecosystems	Mechanisms for Sex Determination in Antarctic Krill	UTAS	Australia	April 2021
43. Ratnarajah, Lavenia	01/12/2013	FT	Carbon & Ecosystems	Effect of natural iron fertilisation by krill and whales on the Southern Ocean carbon cycle	UTAS	Australia	Submitted
44. Richter, Ole	02/05/2016	FT	Oceans & Cryosphere	Tidal melting of Antarctic Ice Shelves since last glacial maximum	UTAS	Australia	November 2019
45. Roden, Nick	14/03/2011	PT	Carbon & Ecosystems	Acidification and Carbonate Chemistry of Shelf Waters in the Australian Antarctic Territory	UTAS	Australia	Submitted
46. Schroeter, Ben	01/02/2016	FT	Oceans & Cryosphere	Towards improved modelling of the high southern latitudes	UTAS	Australia	August 2019
47. 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
48. 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

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49. Semolini Pilo, Gabriela	15/12/2013	FT	Oceans & Cryosphere	Eddies Tridimensional Structure and their Role in Oceanic Mass and Heat Distribution	UTAS	Australia	June 2017
50. Silvano, Alessandra	05/05/2015	FT	Oceans & Cryosphere	Observations of Ocean-Ice Shelf Interaction at the Totten Glacier	UTAS	Australia	November 2018
51. Sow, Swan	20/09/2015	FT	Carbon & Ecosystems	Microbial Oceanography of the Different Water Masses of the Southern Ocean	UTAS	Australia	March 2019
52. Strezelec, Michal	31/05/2016	FT	Carbon & Ecosystems	Source characterisation of atmospheric trace metal deposition around Australia	UTAS	Australia	September 2019
53. Thomton, David	10/08/2015	PT	Oceans & Cryosphere	Evidence of carbon cycle changes from trace gas indicators in polar ice	UTAS	Australia	August 2020
54. 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 - cotele	France/ Australia	April 2018
55. Ward, Delphine	01/10/2014	FT	Carbon & Ecosystems	Evaluating the likelihood of critical transitions in Southern Ocean ecosystems	UTAS	Australia	April 2018
56. Wallis, Jake	31/03/2016	FT	Carbon & Ecosystems	Impacts of ocean acidification on Southern Ocean lower-trophic food pathways	UTAS	Australia	September 2019
57. Warri, Doreen	1/1/2016	FT	Oceans & Cryosphere	High resolution modelling of the retreat of the East Antarctic ice sheet since last glacial maximum	UTAS	Australia	July 2019

Name	Commencement Date	Status	Research Program	Project Title	Research Organisation	Country	Expected Completion Date
58. Weldrick, Christine	1/12/2015	FT	Carbon & Ecosystems	Mapping Planktonic Trophic Pathways Through the Sea Ice Zone	UTAS	Australia	June 2019
59. Yang, Luwei	14/10/2015	FT	Oceans & Cryosphere	Internal Waves and Mixing in the Southern Ocean	UTAS	Australia	April 2019
60. Zhao, Chen	13/10/2014	FT	Oceans & Cryosphere	Ice mass unloading and bedrock response in the southern Antarctic Peninsula	UTAS	Australia	April 2018