IceSked

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Newsletter of Te Puna Pātiotio—Antarctic Research Centre
Te Herenga Waka—Victoria University of Wellington

A word from our Director

After a year off from field work due to COVID-19, Antarctic Research Centre staff and students are excited to be getting back into the field this year. This season is particularly important for us as it will provide a critical stepping stone in our ambition to fulfil the SWAIS 2C project, which we profile in this issue. This project forms a major new international collaboration, and highlights the importance of our partnership with GNS Science in building the Antarctic Intermediate Depth Drill system. This project has been many years in development for both of our institutes and continues the important role New Zealand plays in identifying the sensitivity of Antarctica's ice sheets to climatic warming. We also highlight recent publications and funding success that links Antarctic cryosphere change to offshore oceanic and biological systems.

Rob McKay

Drilling into Antarctica's past to see our future

While COP26 focused on science and innovation's role in combating climate change, our team were preparing to drill into the ocean floor below the Ross Ice Shelf to assess what level of greenhouse gas emissions are likely to avoid catastrophic melt of the icy continent, based on the sensitivity of the West Antarctic Ice Sheet to global warming of 2°C (SWAIS 2C) in past climates. They will achieve this by retrieving sediment cores to reveal if there is a tipping point in our climate system when large amounts of land-based ice melts in these climates, causing oceans to rise many metres—if it has happened before, it could happen again.

The SWAIS 2C team, led by Richard Levy (GNS Science and ARC) and ARC alumni Molly Patterson (now Binghamton University, USA), is an international effort supported by ~ USD$4.6 million in funds from New Zealand, the United States, Germany, Australia, the United Kingdom and the Republic of Korea, with several other nations planning to join. The International Continental Scientific Drilling Programme awarded the project a USD$1.2 million grant, the first for an Antarctic drilling expedition in that programme.

"We have formed a team of drillers, engineers, field experts and scientists who are up to the task. Discoveries will show us how much the West Antarctic Ice Sheet could melt if we miss Paris Agreement targets," Richard says.

SWAIS 2C's preparation team departed from Scott Base in November for a 1200 km traverse across the Ross Ice Shelf to the Siple Coast, where land ice meets the ocean and starts to float. Once the drilling camp has been established, the wider science team will join the group and work through Antarctica's summer. SWAIS 2C field campaigns are planned for the next three years. No one has ever drilled into the Antarctic seabed at a location so far from a major base, or so close to the centre of the West Antarctic Ice Sheet.

The ARC's Science Drilling Office have spent four years developing 'world-first' technology capable of hot water drilling through ~800 m of ice before taking sediment samples from up to 200 m beneath the ice sheet. ARC Director, Rob McKay, says it is a massively ambitious undertaking, but New Zealand engineers such as the ARC's Alex Pyne and Darcy Mandeno are recognised world-leaders in designing and building such innovative technology.

"The fact that so many countries are joining us in this effort highlights the urgency to understand more about the West Antarctic Ice Sheet, which remains the largest uncertainty for sea-level rise projections."

This knowledge will help scientists predict what might happen in the future if global temperatures continue their current trajectory towards 2.7°C above pre-industrial levels, and if we are approaching a climatic threshold for West Antarctic Ice Sheet collapse in the near future. This is important to know because Antarctic ice melt raises sea levels around the globe. The West Antarctic Ice Sheet is considered vulnerable to climate change because much of the ice, which rests on bedrock thousands of metres below sea level, is exposed to the warming Southern Ocean.

A science story: Future of Antarctic plankton linked to sea ice

In a study published in *Nature Geoscience*, a team led by former ARC PhD student Katelyn Johnson (now GNS Science), and involving the ARC's Rob McKay, Nancy Bertler and Huw Horgan, showed that Antarctic sea ice had a tight connection to both Southern Ocean algae blooms and El Niño-linked weather events in the geological past. Investigating a unique 170 metre long sediment core collected by the Integrated Ocean Drilling Programme in 2010, the researchers provided the first ever reconstruction of annual to sub decadal changes in biological primary productivity along the Antarctic marine margin over the entire Holocene epoch (past 12,000 years). Funded by the Royal Society Marsden Fund, the team found Antarctic winds strongly affect the breakout and melting of sea ice, which in turn has an effect on the amount of microscopic algae that grow in surface waters.

Pancake ice in Terra Nova Bay (Photo: Rob Dunbar)

The study used techniques such as CT (computed tomography) scan-imaging and analysis of microfossils and organic biomarkers to examine the relationship between sea ice and large algae bloom events at annual timescales. The researchers found algal bloom events occurred nearly every year prior to 4500 years ago. However, coinciding with a shift towards increased sea ice presence they then became less frequent, occurring every two to five years—a frequency similar to El Niño Southern Oscillation (ENSO) climate events. This provided evidence that ENSO and other climate modes influence multi-year sea ice breakout events, which in turn directly affects biological bloom occurrences. The results of this new paper suggest such changes will have a significant impact on Antarctica's coastal biological system because sea ice amplifies the connection between equatorial processes like ENSO and polar biology, but when sea ice is absent this connection is weakened. With rapid declines in Antarctic sea ice since 2017, and more loss projected over coming future decades, the consequences for polar biology, food webs and polar carbon cycling could be profound.

Solving the mystery of our resident penguin

In 2007, a mummified Adélie penguin was rediscovered in a cupboard at Victoria University of Wellington and passed on to the ARC. Nicknamed Ralph, after Victoria University lecturer Ralph Wheeler who found the penguin in 1960 in Miers Valley, in the Dry Valleys of Antarctica, 35 km from open water and 450 m above sea level.

It's one of many mummified penguins and seals that have been found in the Ross Sea region that are thought to become lost and disorientated, and smelling water in the Dry Valleys, start a long journey in the wrong direction to eventually die of starvation. The cold, dry climate in Antarctica facilitates the preservation of the animals as it's too cold for bacteria or fungi to break down organic matter. Instead, the bodies eventually mummify and only break down due to physical erosion from wind and sand. Ralph was sheltered from these harsh conditions and as a result is relatively well-preserved, only missing a few feathers and the colouration in its feathers. The ARC sent Ralph to a local artist to be installed into its current display box home and has been taken to outreach events for kids ever since.

But one question remained—how long ago did Ralph die? So, in August, Ralph was sent off to the Rafter Radiocarbon Laboratory at GNS Science in hopes of finding out. To do this, the Rafter Radiocarbon team carefully sampled Ralph's feathers. These feathers were chemically treated to remove any contaminants, combusted to CO_2, then converted into graphite, which was measured in the Accelerator Mass Spectrometer to measure the ^{14}C atoms. Only then, did we finally know when Ralph met its unfortunate fate.

The answer—results indicated Ralph died about 104 years ago in 1917, interestingly the same year Sir Ernest Shackleton finally arrived back in England after his heroic expedition on the *Endurance*!

(article modified from New Zealand Antarctic Society publication by Nikita Turton, GNS Science)

Ralph the ARC's mummified penguin (Photo: Jeff Brass, GNS Science)

Marsden success for ARC researchers

The ARC had two successfully funded Marsden grants in the 2021 round awarded by the Royal Society Te Apārangi.

Holly Winton in the National Ice Core Facility at GNS Science

How did changing sea ice conditions impact primary production in the Ross Sea over the past 200 years?

Holly Winton was awarded a $360K Marsden Fast-Start to assess the impacts of changing sea ice conditions on Ross Sea primary production over the past 200 years.

Dramatic and unexplained changes in sea ice conditions in the Ross Sea have been observed over the last decade. Sea ice is one of the major factors driving seasonal phytoplankton blooms which play a crucial role in modulating climate through marine carbon sequestration and the radiation budget. Combining biogenic aerosol observations, phytoplankton biomarker records from ice cores and biogeochemical modelling, this project will extend the short observational records of primary production and sea ice to quantify sea ice-primary production relationships.

The team includes biogeochemical modeller Angela Bahamondes Dominguez from the Antarctic Science Platform National Modelling Hub and NIWA. The team is also made up of atmospheric chemists, atmospheric physicists and paleoclimatologists from the University of Waikato, the British Antarctic Survey, the University of Cambridge and the Spanish Institute of Marine Science.

Can snow change the fate of Antarctic sea ice?

Our other success was a $913K standard Marsden awarded to Ruzica Dadic to investigate the role of snow cover on the evolution of Antarctic sea ice to test the hypothesis that a persistent snow cover could prevent, or slow, a decline of Antarctic sea ice in response to a warming climate. Because of its highly insulating and reflective properties, snow cover on sea ice dominates the energy fluxes between the ocean and the atmosphere, yet data on the physical properties of snow and its effects on sea ice are limited. This lack of data leads to significant biases in model representation of sea ice variables and large uncertainties in how sea ice influences global climate.

Ruzica Dadic in the Arctic (Photo: Lianna Nixon)

This Marsden project will combine field and laboratory measurements with multi-scale modelling to improve the representation of snow processes in predictive models of sea ice evolution in the context of climate change. This project will also help publish a children's picture book that combines Māturanga Māori and Antarctic snow/ice science.

Master's scholarship awarded in memory of Roger Cooper

In 2020, Te Herenga Waka—Victoria University of Wellington alumni, Professor Emeritus James Kennett, gave a donation to the ARC in memory of his friend and colleague Dr Roger Cooper FRSNZ, who passed away on 2 March 2020. Roger and James were classmates at Victoria University in the 1960's. Roger had conducted field work in Antarctica, and convinced James he should go the following year. In James's own words, "It changed my life. Roger continued to inspire and encourage me in years to follow." Roger was one of New Zealand's pre-eminent paleontologists. His contributions to our understanding of Zealandia's rich geological and paleontological histories are enormous.

Long-time friends, James Kennett (left) and Roger Cooper (right)

The ARC decided to use the funds to support the next generation of paleo-scientists, awarding the "Roger Cooper Masters Scholarship" to Emma de Jong. Emma's MSc project, starting in 2022, will use ancient molecular fossils called biomarkers, to look at phytoplankton in the Ross Sea. Using marine sediments and ice core samples to create a spatial distribution, this project will hopefully help extend the short, sparse records of past phytoplankton community composition and abundance. The scholarship will support Emma with her studies by providing full fees and a stipend and has increased her confidence pursuing an environmental science degree.

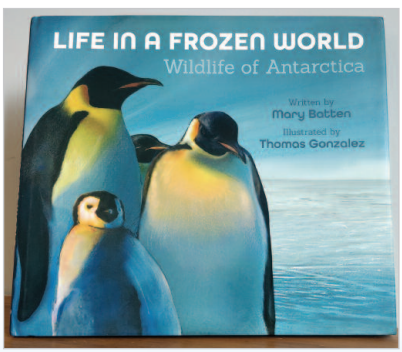
In her thank you letter to James, just as Roger had inspired James all those years ago, Emma said, "You have inspired me to continue in academia, and I hope that one day I can give back to the community like you have."

New Modelling Hub Winter School

The Antarctic Science Platform National Modelling Hub recently held its inaugural "Winter School" on 18-19 October at Victoria University of Wellington's Pipitea campus (after postponement due to the COVID-19 lockdown in August). The two-day workshop consisted of a mix of lectures and hands-on interactive sessions focused on numerical modelling, data analysis, and computational techniques for Earth and climate sciences. Aimed at postgraduate students as well as ARC staff wishing to update and diversify their skill sets, it was an opportunity to learn practical skills not taught as part of the standard geoscience curriculum and meet colleagues working in different subject areas. The workshop covered general principles of coding, climate models, time-series analysis, plotting in 3D, writing in Latex, and workflow and version control. Despite having a wide range of existing skills, from beginner to advanced, all participants indicated that they learned something new that they hope to be able to use in their future research. With a successful first run, plans are in place to hold the school again next winter.

Collaboration on children's book

In April 2019, Nick Golledge was contacted by award-winning nature writer Mary Batten, an American author who has written many non-fiction works for both adults and children. She was working on her latest book, *Life in a Frozen World*, about the wildlife of Antarctica. In writing for a younger audience about the environmental issues we currently face, Mary needed some up-to-date figures for future sea level projections, and through a series of emails Nick was able to not only provide the numbers, but also some insight into why some of these estimates still remain uncertain.



In the book, Mary has managed to communicate the sometimes-baffling science of Antarctic ice sheet dynamics to the next generation in a clear and meaningful way that tells it like it is whilst still retaining a sense of optimism. The book is suitable for ages 6-10 years, is beautifully illustrated, and is widely available online. (www.peachtreebooks.com/book/life-in-a-frozen-world/)

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