The Changing Antarctic and Southern Ocean and Pathway to Policy

(Image credit: Fiona Elliott/NIWA)

The Southern Ocean plays a major role in global climate. What happens in this fast-changing region will have huge impacts on New Zealand in the coming decades. Understanding the transformations taking place in the Southern Ocean and ensuring this knowledge is reflected in government policy are of major importance in New Zealand's response to the climate crisis.

These concerns of course extend globally. We are a few months into the UN Decade of Ocean Science for Sustainable Development, which aims to create a common framework to strengthen science-policy connections and enhance the management of coasts and oceans for the benefit of humanity. Even with a pandemic, understanding and containing the changing ocean remains one of our species' big challenges. Despite its importance, the Southern Ocean is relatively unstudied and there is much we still need to learn about the effects of planetary warming. What can a decade of Antarctic Ocean science bring us, and how does the Antarctic Science Platform fit in? And how can we connect to government policy?

Key Scientific Issues in Understanding the Changing Ocean

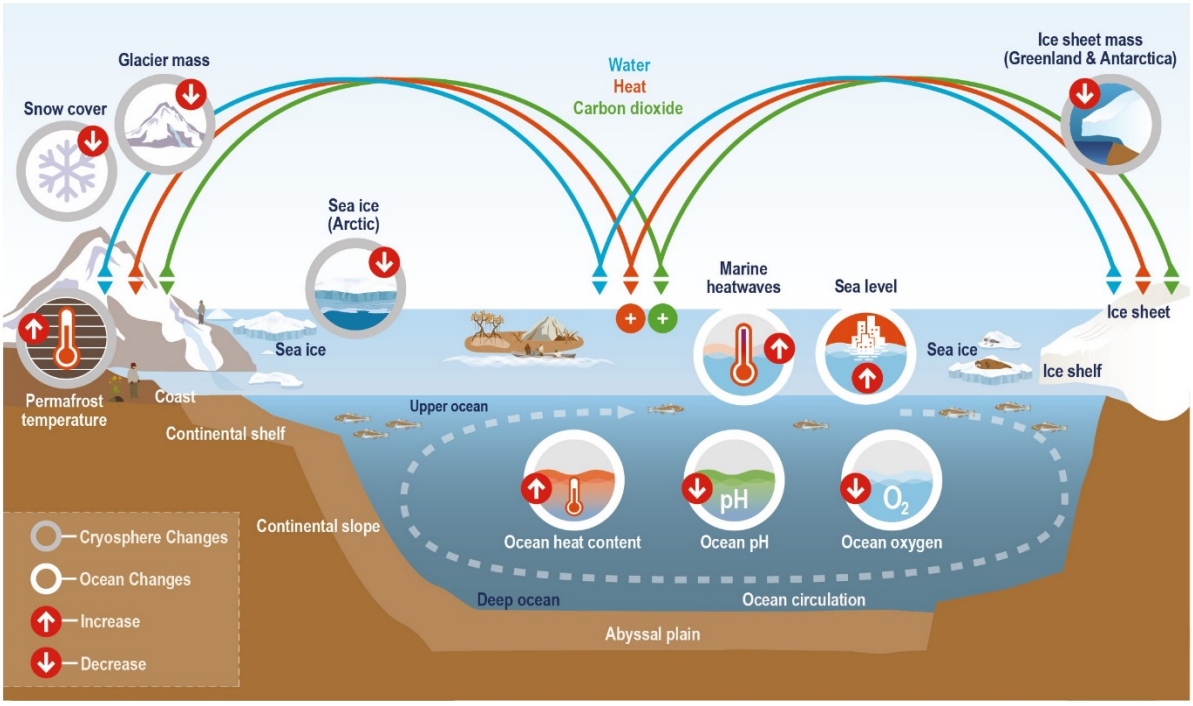
One of the overarching indicators for ocean health is ***Southern Ocean heat content.*** The oceans store 93% of the extra heat being generated from human-induced climate change. A significant proportion of this is going into the Southern Ocean. New Zealand holds jurisdiction over a large area of the Southern Ocean and so there are important policy considerations that emerge from this research.

Heat content of the oceans might seem like an abstract quantity, but it underpins life on this planet. If all the excess heat from climate change had gone into the atmosphere instead of the oceans, global temperatures would already have jumped by over 50 degrees. Ocean heat hugely affects biological productivity in the ocean which impacts everything from offshore fisheries to coastal

ecosystems. It also plays a significant role in our weather and influences damaging events like tropical cyclones, drought and bushfires.

The Southern Ocean is warming at about twice the average rate of the global ocean. While still a relatively cold part of the planet, this large departure from normal temperatures has the potential to rapidly destabilise climatic patterns and increase the melting of Antarctic ice sheets.

As well as absorbing heat, the Southern Ocean is a ***carbon sink***, absorbing carbon dioxide from the atmosphere. Changes in the rate of carbon absorption will impact how quickly the planet warms, if more carbon dioxide ends up in the atmosphere rather than the ocean. More carbon dioxide in the ocean also makes the water more acidic, which affects marine life.



Schematic illustration of key components and changes of the ocean and cryosphere, and their linkages in the Earth system through the global exchange of heat, water, and carbon. (Image credit: IPCC)

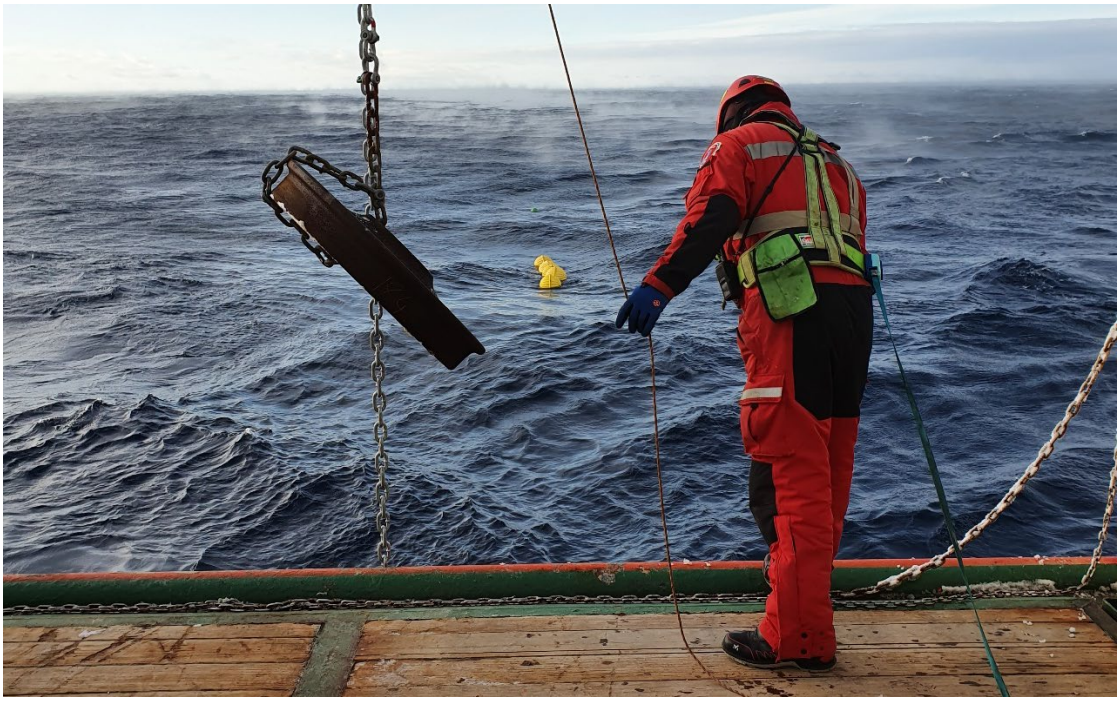
Sea level rise is perhaps the best studied phenomenon by which changes in Antarctica will be transmitted globally, including to Aotearoa New Zealand, by the oceans. There is more we need to understand about ocean interactions with marginal ice around Antarctica and how changing ocean conditions impact on ice melt, in order to reduce uncertainties over sea-level rise to a level useful for policy-making.

The ***cycle of sea ice*** extent and thickness is one of the defining features of our planet: an area of floating ice roughly equal to the size of the Antarctic continent forms and melts away each year. Yet there remain major challenges in forecasting sea ice from year to year. It is difficult to model the formation of a material which involves complex physical changes and can be affected by storms thousands of kilometres away. Added to this are the uncertainties that arise from a warming ocean and changing weather patterns, and it is clear that much more data is needed. Enhanced knowledge of sea ice persistence will benefit both science and operations in Antarctica.

Data Transparency and Availability

The changes happening in the Southern Ocean are very complex and involve interactions across the entire ice-ocean-atmosphere system. Making sense of it all requires changes not only in data

collection, but also in data transparency and availability. Lack of access to ocean data limits our ability to provide confident answers to stakeholder questions. Remote sampling is improving this situation, as are recent advances in Argo, an international network of floating instruments which measure ocean data. However, challenges still remain at higher latitudes.



(Image credit: Sarah Searson/NIWA)

Having access to these vast amounts of data once it has been collected is another challenge. This is why participation in global initiatives is essential. Initiatives such as SOOS (Southern Ocean Observing System, a subset of GOOS, Global Ocean Observing System) are working hard at making data findable and changing the nature of science. The array of data and situations being monitored can be daunting, and in response GOOS developed the concept of Essential Ocean Variables to provide a consistent framework to minimize costs and enable comparability.

At a local level this connects with recent reviews by the Parliamentary Commissioner for the Environment who examined environmental reporting in Aotearoa and called for greater national coordination. The Ross Sea Marine Protected Area provides a structured pathway between ocean science and policy. There is still much work to be done in the policy space, however. A more unified Oceans policy and greater focus on the importance of the Southern Ocean in shaping New Zealand's climate future will enhance the translation of research into effective responses to the pressing challenges we face.

An important thread in the decade of ocean science is who is doing the science and where. This seeks to empower people, communities, and nations who have struggled to have and build a stake in ocean knowledge. The Deep South National Science Challenge has made aspects of this a priority.

Antarctic Science Platform Research

The Antarctic Science Platform is developing an inventory of ocean data for the Ross Sea Sector. The Platform has already built an energetic and diverse research team, and embarked on a substantial step forward in quantifying and cataloguing Essential Ocean Variables for the ASP focal region of the Ross Sea that stretches from the grounding line of the Ross Ice Shelf to the continental shelf break

and beyond. This underpins UN Sustainable Development Goals 13 and 14 and provides New Zealand science with international mana. Our participation in global initiatives such as SOOS and the SCAR Research Programme AntClimNow seeks to build these pillars of transparent data and understanding of impact.

However, it remains for policy documents like the Antarctic and Southern Ocean Research Priorities and Directions to fully embrace the Southern Ocean and the interfacial role it plays in connecting New Zealand to Antarctica. Complex issues like ocean heat content need to be explained and made relatable. In this way the decade of ocean science can become a decade of opportunity to provide the evidence for improving the world around us.

References/Reading

Bronselaer, B., Winton, M., Griffies, S.M., Hurlin, W.J., Rodgers, K.B., Sergienko, O.V., Stouffer, R.J. and Russell, J.L., 2018. Change in future climate due to Antarctic meltwater. *Nature*, *564*(7734), pp.53-58. https://doi.org/10.1038/s41586-018-0712-z

Climate Change Commission https://www.climatecommission.govt.nz/get-involved/our-advice-and-evidence/

Hu, A. and Bates, S.C., 2018. Internal climate variability and projected future regional steric and dynamic sea level rise. *Nature communications*, *9*(1), pp.1-11. https://doi.org/10.1038/s41467-018-03474-8

Oliver, E.C., Burrows, M.T., Donat, M.G., Sen Gupta, A., Alexander, L.V., Perkins-Kirkpatrick, S.E., Benthuysen, J., Hobday, A.J., Holbrook, N.J., Moore, P.J. and Thomsen, M.S., 2019. Projected marine heatwaves in the 21st century and the potential for ecological impact. Frontiers in Marine Science, 6, p.734. https://doi.org/10.3389/fmars.2019.00734

Rintoul, S.R., Chown, S.L., DeConto, R.M. *et al.* Choosing the future of Antarctica. *Nature* **558,** 233–241 (2018). https://doi.org/10.1038/s41586-018-0173-4

Scott K (2021). Does Aotearoa New Zealand Need an Oceans Policy for Modern Oceans Governance?. Ocean Yearbook. 35. https://hdl.handle.net/10092/100954

Sutton, P.J. and Bowen, M., 2019. Ocean temperature change around New Zealand over the last 36 years. *New Zealand Journal of Marine and Freshwater Research*, *53*(3), pp.305-326. https://doi.org/10.1080/00288330.2018.1562945

Article prepared by Craig Stevens and the Antarctic Ocean Mechanics team, with support from Rowan Howard-Williams. For more information contact Craig Stevens craig.stevens@niwa.co.nz