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# The importance of long-term research and monitoring in the Ross Sea

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The Ross Sea region is a biologically rich and dynamic environment and, although protected under various instruments of the Antarctic Treaty System, is threatened by a changing climate and increasing human activities locally and globally. This opinion editorial describes the importance of research and monitoring in the Ross Sea and identifies opportunities and barriers to enhance them.

Long-term quantitative monitoring is needed to provide information about current environmental conditions and the dynamics of environmental indicators. Monitoring is a key tool for managers to determine when a system is influenced by human impacts, and whether it is necessary to adapt their management approach. Where monitoring data are insufficient, managers must rely on qualitative judgment and precaution to assess environmental conditions.

The Ross Sea has experienced among the least human impacts of the world's marine environment (Halpern et al, 2008, 2015) and is therefore an ideal laboratory for research into local and global impacts of human activities. Environmental research and monitoring in the Ross Sea have long legacies, beginning around the turn of the twentieth century when British expeditions made extensive biological collections. Research, driven in part by the rich fauna of the region, the location of scientific bases and the toothfish fishery, has contributed to the Ross Sea being one of the most intensively studied regions in the Southern Ocean.

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The importance of Antarctic science was recently emphasized when the Scientific Committee on Antarctic Research (SCAR) convened 75 scientists and policy-makers from 22 countries to agree on the priorities for Antarctic research (Kennicutt et al., 2014). Many of the questions identified illustrated the major role science will play in mitigating environmental impacts and in providing the information required for policy development (Chown et al., 2015). Answering these questions will require: (1) access to all of Antarctica throughout the year, communications across and from the region, and the application of emerging technologies; (2) strengthened protection of the region; (3) sustained funding; and (4) growth in international cooperation (Kennicutt et al., 2014)[1]. I discuss these factors below.

## 1 New technologies

New and developing remote sensing technologies enable the collection of detailed, uniform quality and near real-time information allowing the discrimination of temporal and spatial patterns and the use by operational environmental models (BAS, 2019; SCAR, 2019). For example, satellite remote sensing allowed a synoptic survey of the entire population of emperor penguins to be undertaken in a single year (Fretwell et al., 2012) and enabled the counting of Weddell seals in the Ross Sea (LaRue et al., 2019). Robotic Argo floats have measured more than 45000 ocean profiles south of 60°S since 2001

(The Polar Argo Task Team, 2019). Autonomous vehicles can operate in the air and underwater, including under the ice, with new sensors that can collect a wide range of data (Piermattei et al., 2018).

The CCAMLR Ecosystem Monitoring Program (CEMP) was established in 1989 to record significant changes in the marine ecosystem and to distinguish between human impacts and environmental variability (CCAMLR, 2013) CEMP tends to rely on more traditional research approaches. CCAMLR's Scientific Committee is reviewing the Commission's ecosystem monitoring requirements and the role of CEMP (CCAMLR, 2018, see Paragraph 3.23) and I encourage this review to consider the role of new technologies.

## 2 Marine protection

The potential ecological benefits of Marine Protected Areas (MPAs) are well documented, including increasing fish biomass and diversity and the dispersal of larvae and adults of target and non-target species to areas outside their borders (Pendleton et al., 2018). MPAs can also enable research and monitoring outcomes potentially compromised by fishing such as the establishment of scientific reference areas and understanding environmental change un-confounded by human impacts (Delegations of New Zealand and the USA, 2013). This is recognised by CCAMLR's framework for establishing MPAs, together with a range of ecosystem protection objectives[2].

The Ross Sea Region MPA (RSRMPA) was created in 2016 and came into force in December 2017. Specific objectives of this MPA include providing reference areas for monitoring natural variability and long-term change; and promoting research and monitoring on marine living resources[3]. A research and monitoring plan (RMP) is being developed to help determine the degree to which the objectives of the MPA are being achieved, the relevance of the MPA objectives and what management actions may be required to improve the achievement of the objectives (Dunn et al., 2017). The RSRMPA and its associated RMP provide an excellent basis to deliver much of the research suggested by SCAR. Although endorsed by the Scientific Committee, the RMP has not yet been adopted by the Commission due to objections by two member countries, China and Russia (CCAMLR, 2018, see Paragraphs 6.6–6.9 and 6.10–6.16).

## 3 Capacity and funding

As the RSRMPA is a CCAMLR MPA, research and monitoring are the responsibility of all Members of the Commission, although not all Members are willing or able to invest in research in this part of Antarctica. The USA McMurdo, New Zealand Scott Base and the Italian Mario Zucchelli research stations have been playing critical roles in Ross Sea research. China and Korea (ROK) are well placed to play important roles with icebreakers *Xuelong* and the newly commissioned *Xuelong* 2, and *Araon*, respectively and research stations in Terra Nova Bay in the Ross Sea. Several countries are already conducting research in the Ross Sea associated with the RMP (CCAMLR, 2018, see Paragraphs 6.30–6.34). Some Members are experiencing political and economic uncertainty, but given profound changes in climate and biodiversity globally this is not the time to compromise long-term environmental monitoring programs.

## 4 International collaboration

Collaboration can reduce costs and increase effectiveness of research in the Southern Ocean. Collaboration can occur formally, such as China-Australia Joint Committee on Antarctic and Southern Ocean Collaboration and a similar committee between China and New Zealand. Collaboration can also occur informally. For example, a Korean scientist participated in the New Zealand research vessel *Tangaroa* voyage in 2018, investigating phytoplankton growth rate, microzooplankton grazing rate and carbon fluxes. During the 2019 *Tangaroa* voyage a Chinese scientist conducted phytoplankton, zooplankton, fish and invertebrate sampling. These individual collaborations represent great opportunities and I am aware that there are many other examples of informal collaboration between Members.

Collaboration is also helped by knowing who is doing what. For example, the RSRMPA RMP will include an electronic database that will detail the projects that Members have proposed, are undertaking, or have undertaken to address the RMP topics (Dunn et al., 2017). The CCAMLR Scientific Committee has a key role to promote cooperation[4]. Indeed, the Scientific Committee recognises the importance of collaboration—a good example is the joint workshop on cooperation held between the Scientific Committee of CAMLR and the Southern Ocean Observing System (SOOS) in 2018 (CCAMLR, 2018, see Paragraphs 9.9 and 10.9)

The Ross Sea region is the ideal laboratory for research into local and global impacts of human activities. Research and monitoring are important for the international management of this region. The global importance of Antarctic science has been emphasized by SCAR, noting that this required emerging technologies to access to all of Antarctica throughout the year; strengthened protection of the region; sustained funding; and growth in international cooperation.

The CAMLR Commission and its Scientific Committee have clearly defined roles and all Members have responsibilities to address these issues. The recently created RSRMPA not only serves to mitigate fishing impacts and increase resilience to climate change, but its research and

monitoring plan provides an opportunity and framework for international co-operation. New technologies are providing cost effective methods for research and monitoring in areas and at times that previously were unfeasible. Effective and efficient monitoring and the sharing of knowledge are best achieved through international collaboration—one of the pillars of the Antarctic Treaty. The RMP being developed as part of the RSRMPA provides an open, transparent and collaborative framework for conducting research in the Ross Sea region. It is up to all CCAMLR Members to endorse the RMP and facilitate its implementation.

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## Endnotes

[1] Note that the issues have been amalgamated and re-ordered.

[2] The others are: (i) the protection of representative examples of marine ecosystems, biodiversity and habitats…; (ii) the protection of key ecosystem processes, habitats and species…; (iv) the protection of areas vulnerable to impact by human activities…; (v) the protection of features critical to the function of local ecosystems; (vi) the protection of areas to maintain resilience or the ability to adapt to the effects of climate change.

[3] Section 3 of Conservation Measure 91-05.

[4] Article XV (1) of the Convention states that the Scientific Committee "shall encourage and promote co-operation in the field of scientific research in order to extend knowledge of the marine living resources of the Antarctic marine ecosystem".