The Ross Sea:
A Valuable Reference Area to Assess the Effects of Climate Change
Summary

International Panel on Climate Change models predict that the Ross Sea will be the last portion of the Southern Ocean with sea ice year round. Currently, the Ross Sea ecosystem is considered to be relatively little affected by direct human-related impacts other than the past exploitation of marine mammals along its slope and the recent exploratory Antarctic toothfish fishery. The indirect human impacts of CO2 pollution on melting ice and ocean acidification have yet to be felt. The Ross Sea - with its several very long biotic and hydrographic data sets - constitutes an important reference area to gauge the ecosystem effects of climate change and distinguish those effects from the effects of current fisheries, tourism, and historic overexploitation and recovery or lack of recovery of some seal, whale, and fish populations elsewhere. This, in conjunction with a range of other scientific and biological reasons that has been laid out in prior ASOC papers, underpins why the Ross Sea should be included as a key component in the network of marine protected areas currently being considered for the Southern Ocean by the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR).

1. Introduction

Over the past few years, ASOC has put forward a number of papers making the ‘science case’ for supporting full protection of the Ross Sea slope and shelf,1 in the context of establishing an important component of a representative network of MPAs in the Southern Ocean.2 This paper focuses on the climate reference zone potential of the Ross Sea.

2. Background

Models used by the International Panel on Climate Change (IPCC) that best duplicate current conditions in the Southern Ocean predict that the Ross Sea will be the last portion to have sea ice year round.3 Sea ice coverage in the Ross Sea (both the length of the ice season and the amount of ice) is expected to continue growth over the next few decades, but thereafter expected to decline although it will be present long after it no longer forms in the remainder of the Southern Ocean. Therefore, the Ross Sea will be a ‘refugium’ for the study of normal ice processes and associated biota, and can serve as an important reference area to help gauge the magnitude and the ecological and economic significance of changes elsewhere in the Southern Ocean and in other cold ocean ecosystems.

During the Last Glacial Maximum, the northwestern Ross Sea continental shelf was one of the few portions, if indeed there were any other portions, of the Antarctic continental shelf that was not covered by an ice sheet,4 and was open owing to a polynya in that location.5 Therefore, the Ross Sea shelf and adjacent slope were a biotic refugium, possibly explaining the high degree of endemism there now6, and the existence of biota such as barnacles and anchored alga (seaweed). It will become a different sort of refugium later in this century, if current trends in climate and the loss of sea ice continue, providing a last location for many of the pagophilic (ice loving) species now present in and dependent on the seasonally and permanently ice covered parts of the Southern Ocean. It also will become the last refugium for studies to determine what and how

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1 At the 2010 CCAMLR meeting ASOC introduced “The Case for Including the Ross Sea Continental Shelf and Slope in a Southern Ocean Network of Marine Protected Areas”: http://www.asoc.org/storage/documents/Meetings/CCAMLR/XXIX/ASOC_Ross_Sea.pdf.
3 See IPCC 2007 Report, Lefebvre & Goosse 2008, Russell in Ainley et al. 2010a; Turner et al. 2009 report only that it will be an area much less affected by sea ice loss that other portions of the Southern Ocean.
4 Anderson 1999.
5 Thaljie et al. 2008.
6 ASOC 2010, Ainley et al. 2010b.
different species and biological communities adapt, or fail to adapt, to diminishing sea ice and increasing ocean temperatures.

Significant and possibly accelerating changes to the Southern Ocean driven by climate change no doubt are affecting or will affect fishery resources and dependent and associated species, posing a major challenge to the effective implementation of the Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR). Achievement of the innovative ecosystem conservation objective set forth in Article II of the Convention is dependent upon being able to distinguish the impacts of fishing and associated activities from natural environmental variation. The ways and rapidity that climate change affects the distributions, abundance and productivity of fishery target species, and their ecological relationships with dependent and associated species, will greatly complicate decision-making and thereby threaten to undermine implementation of Article II itself. What is called for is a proactive and systematic research, monitoring and adaptive management program to distinguish the effects of fishing and associated activities from those of climate change. The designation of the Ross Sea shelf and slope as a special area for protection and scientific study, as provided for in CCAMLR Article IX (2) (g), would provide an invaluable step toward the development and implementation of a research and management strategy to meet the challenge of effective implementation of the Convention.

As a result of decades of research beginning during the 1957-58 IGY, the Ross Sea now is the site of five of the longest ecological data series in the Southern Ocean:

- Adélie penguin population statistics since 1959\(^7\)
- Species composition and growth of near-shore benthic communities since the late 1960s\(^8\)
- Demography and population numbers of Weddell seals since the late 1960s\(^9\)
- Antarctic toothfish population statistics since 1974\(^10\)
- Hydrographic properties since the 1960s\(^11\)

Moreover, the benthic fauna, studied more intensively than anywhere in the Southern Ocean, constitute an unparalleled reference to climate-related change, beginning with the >400 types specimens logged since the 1840s,\(^12\) the earlier Ross Sea-wide survey work reported in Bullivant\(^13\) and Barry\(^14\), but most recently results from the latitudinal gradient project led by New Zealand.\(^15\)

These data series have been important in our attempt to understand biological and ecological responses to interannual, decadal and longer-term climate change. They will increase in value with each passing year as long as the effects of climate change do not become confused by the effects of fisheries or other activities in the area. Currently, the Ross Sea is considered to be the least anthropogenically impacted ocean area remaining on Earth.\(^16\)

Owing to its long-term history of scientific activities, the Ross Sea was one of the first areas of the Southern Ocean in which the short-term effects of the El Nino-Southern Oscillation (ENSO) were detected.\(^17\) It was also among the first areas where decadal climate patterns related to the Southern Annular Mode (SAM) were detected in the fauna.\(^18\) Both of these important, short-term climate change signals are now well known to

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7 Wilson et al. 2001.
8 Dayton 1989, Kim, Conlan, Dayton et al. unpubl. data.
9 Cameron & Siniff 2004.
10 Devries et al. 2008.
12 See footnote 6.
13 Bullivant 1967.
14 Barry et al. 2003; see footnote 6.
15 http://www.sciencepoles.org/articles/article_detail/shulamit_gordon_discusses_the_latitudinal_gradient_project/; see also Thrush et al. 2010.
17 Testa et al. 1991; see also review in Ledley & Huang 1997.
ecologists working elsewhere and are key to detecting longer-term changes and trends in species’ responses to climate change.

Longer-term trends in the Ross Sea are part of a climate ‘see-saw’ or oscillation that complements contrasting trends in the Antarctic Peninsula region. This spatial oscillation is related to SAM, known also as the Antarctic Oscillation, and is best seen in the behavior of sea ice contrasted between the two regions – (Antarctic Peninsula versus Amundsen/Ross Sea). Since the mid-1970s, due to the Antarctic Ozone Hole and warming of mid latitudes, SAM has been stuck in a positive mode. As a result, in the Ross Sea region, sea ice coverage, which includes seasonal formation, melt and extent, has been increasing - and is expected to continue to increase, while in the Antarctic Peninsula region sea ice coverage has been decreasing and is expected to continue to do so. Elsewhere in the Southern Ocean, sea ice coverage has so far shown minimal long-term climate effects.

While there is much concern regarding the corresponding decrease in Antarctic krill as sea ice coverage decreases in the Antarctic Peninsula region, it is changes in populations of Adélie, chinstrap and gentoo penguins that illustrate how the pack ice biota is responding to SAM. In the Ross Sea region, where 38% of the world population of Adélie penguins resides, their populations have been increasing as sea ice coverage and coastal polynyas both increase, owing to increasing offshore winds. On the other hand, in the Antarctic Peninsula region, the opposite trend in sea ice, owing to the wind regime, has led to receding sea ice and the southward retreat of Adélie penguin and chinstrap penguin populations; to some degree these penguins are being replaced by the closely related gentoo penguin.

CCAMLR has chosen the Adélie and gentoo penguins to be ‘indicator’ species in its Ecosystem Monitoring Program (CEMP) for good reason. CCAMLR’s Scientific Committee consider that other more difficult-to-monitor pack ice species are likely to be changing in unknown ways in concert with the ongoing changes in these penguin species.

The biological and ecological effects of climate change in the Antarctic Peninsula region can be confused with the effects of the krill fishery, tourism, and the historic overexploitations - and recovery or lack of recovery of some seal, whale, and fish populations. Except for the relatively recent development of the ‘exploratory’ commercial fishery for Antarctic toothfish, the biological communities and food webs of the Ross Sea shelf and slope area are comparatively pristine. Therefore, they offer a unique opportunity for developing research, monitoring and management programs that will enable distinguishing the effects of climate change from those of fisheries and other activities in the Southern Ocean. This will minimize climate-related challenges to the effective implementation of CCAMLR.

3. Conclusion

In order to enhance our ability to understand marine ecosystem processes as they respond to climate change, and to facilitate the collective conduct of science, the Ross Sea shelf and slope must be included in the network of marine protected areas now being instituted in the Southern Ocean. The Ross Sea foodweb and ecosystem processes should be protected from extractive activities that will compromise its value as a reference area.

Looking ahead to the August MPA workshop in Brest, France, ASOC urges all Antarctic Treaty Consultative Parties to give open-minded consideration to according MPA status to the Ross Sea, based on the data and scientific arguments contained in two detailed bioregionalization papers presented by the US to the 2010

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19 Turner 2009.
20 Thompson & Solomon 2002, Russell et al. 2006a, b; Stammerjohn et al. 2008.
meeting of the CCAMLR Working Group on Ecosystem Monitoring and Management, and the ASOC papers presented at the ATCM and CCAMLR meetings of the past few years.

4. References

ASOC. 2010. The case for inclusion of the Ross Sea continental shelf and slope in a Southern Ocean network of marine reserves. ATCM 33, IP077.


