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THE CASE FOR A ROSS SEA MARINE RESERVE

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THE CASE FOR A ROSS SEA MARINE RESERVE

Abstract

The Ross Sea continental shelf and slope have a number of characteristics that make it an ideal candidate for a marine reserve, as evidenced by its inclusion in the list of 11 priority areas, which focuses efforts on MPA designation where there are high levels of biological heterogeneity.[1] With exceptional biodiversity and evolutionary significance, as well as its potential as a climate change reference area and refuge and its value for scientific research, the Ross Sea merits comprehensive protection of its entire continental shelf and slope. Much of the scientific and biological importance of the Ross Sea derives from its relatively pristine state, which will be irrevocably altered by the continuation of fishing. Preservation of the Ross Sea's unique qualities therefore requires the designation of a no-take MPA encompassing the shelf and slope. Scientific information presented to CCAMLR and the ATCM since 2002 has developed a clear case for the designation of the Ross Sea shelf and slope as a marine protected area (MPA) by CCAMLR. This paper summarizes the scientific basis for comprehensive Ross Sea protection.

1. Introduction

Scientific information presented to CCAMLR and the ATCM for the past several years has developed a clear case for the designation of the Ross Sea shelf and slope as a marine protected area (MPA) by CCAMLR. The case rests primarily on three factors:

- Evolutionary significance and high levels of biodiversity of the Ross Sea;
- The value of the Ross Sea as a climate change refuge for biota, and as a reference area for climate change research; and
- The Ross Sea's importance for scientific research given its comparatively least impacted status relative to other marine regions, and the existence of long-term scientific data bases.

This paper examines briefly each of these factors and summarizes the scientific basis for comprehensive Ross Sea protection.

2. Evolutionary significance and high levels of biodiversity

The Ross Sea possesses a high level of habitat diversity due to its physical characteristics, namely a "shallow shelf with deep troughs bordering shallow banks, a complexity of water types, and a complexity of circulation and water flow rates in part determined by topography." (Ainley et al. 2010[2]). Due to this habitat diversity, the diversity of invertebrate fauna is also high and the Ross Sea has been labeled a biodiversity "hotspot." Benthic communities have been particularly well-studied and research results clearly demonstrate unusually high species richness. The Ross Sea is the type locality for over 400 benthic invertebrates. Biodiversity is not confined to the benthos, however. Although the Ross Sea is highly productive, it has relatively low levels of zooplankton. Thus its unusually robust pelagic assemblage of numerous large fish, sea birds, penguins, pinnipeds and whales is somewhat paradoxical. This results from a foodweb more columnar than pyramidal, with much of the existing carbon residing in the upper trophic levels.

The Ross Sea provides habitat for large percentages of the world's populations of many higher trophic level species, including emperor penguins (*Aptenodytes forsteri*) (26%), Antarctic petrels (*Thalassoica antarctica*) (30%), Adélie penguins (*Pygoscelis adeliae)* (38%), South Pacific Weddell seals (*Leptonychotes weddellii)* (45%), and Ross Sea killer whales (*Orcinus orca*, Type C) (50%).[3][4] Since the Ross Sea only occupies 2% of the Southern Ocean but contributes 28% of total primary production, the region has disproportionate significance in terms of habitat for these species. Over 40 species are found in the Ross Sea and nowhere else. Furthermore, important components of the Ross Sea upper trophic level fauna such as penguins, toothfish, and Weddell seals require the entire Ross Sea shelf and slope to complete their annual cycle.

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[1] SC-CAMLR XXVII Final Report, paragraphs 3.53 and 3.60

[2] Ainley, DG, G Ballard, and J Weller (2010). Ross Sea Bioregionalization. WG-EMM 10/11.

[3] Van Franeker, J.A., M. Gravilo, F. Mehlum, R.R. Veit & E.J. Woehler. 1999. Distribution and abundance of the Antarctic petrel. Waterbirds 22: 14-28.

[4] Woehler, E. J. 1993. The distribution and abundance of Antarctic and sub-Antarctic penguins. Cambridge, UK: Scientific Committee on Antarctic Research.

The Ross Sea is also important in evolutionary terms. In addition to possessing numerous endemic species mentioned above, its notothenioid fish comprise a unique marine example of an evolutionary radiation known as a "species flock." one group, the plunderfishes, evolved and radiated from the Ross Sea. Although there are only 95 fish species in the Ross Sea, the diversity of these fish is more relevant than their numbers. The waters of the High Antarctic shelf form a unique evolutionary site where the abundance, biomass, morphological and ecological diversity of the dominant notothenioid fishes overshadow the relatively small number of species.[5] The radiations of other high Antarctic groups, including lobodontine seals and some lineages of bryozoans, pycnogonids, echinoderms, amphipods and isopods, provide additional evidence that the Ross Sea is a noteworthy evolutionary locality. In addition there are three recently diverged species of killer whales in the Ross Sea, including the newly recognized Ross Sea killer whale, a smaller form. A unique genotype of the Adélie penguin, and one of the Weddell seal, are found only in the Ross Sea.

3. Climate change refuge and reference area

The case of the Ross Sea marine reserve as a climate change refuge has been elaborated in a paper presented earlier this year to the ATCM.[6] International Panel on Climate Change (IPCC) models predict that the Ross Sea will be the last region on Earth to retain sea ice year round. These models indicate that sea ice will increase in the Ross Sea over the next few decades, but will then decline. However, ice will still be present whereas in the rest of the Southern Ocean it will have disappeared. The Ross Sea will therefore be an ideal location to study normal ice processes and associated biota, serving as a reference area researchers can compare with other regions of the Southern Ocean to help understand the ecological and economic significance of changes occurring there and in other cold ocean ecosystems.

As an area with sea ice, the Ross Sea will likely be a refuge for ice loving species such as Adélie penguins, emperor penguins, Weddell seals, and snow petrels. Climate change will also no doubt affect fish populations, and the Ross Sea can be a valuable area for researchers seeking to develop effective implementation of ecosystem-based management in a rapidly changing environment. The ways 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 under the Convention on the Conservation of Antarctic Marine Living Resources. A marine reserve comprising the Ross Sea shelf and slope would be a vital component of a proactive and systematic research, monitoring and adaptive management program to distinguish the effects of fishing and associated activities from those of climate change.

Longstanding data series from the Ross Sea on Adélie penguin populations, species composition and growth of near-shore benthic communities, demography and population numbers of Weddell seals, Antarctic toothfish population statistics, and hydrographic properties have all been important in the attempt to understand biological and ecological responses to interannual, decadal and longer-term climate change in the south polar region. Many are the longest available of their kind. These time series 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.

The biological and ecological effects of climate change in other areas of the Southern Ocean, particularly the Antarctic Peninsula, can be confused with the effects of the krill fishery, tourism, and the historic overexploitations of seal, whale and demersal 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 are comparatively pristine, particularly on the shelf and slope.[7] This presents an opportunity for scientists to obtain information that could inform an ecosystem-based approach to CCAMLR managed fisheries even though climate impacts may be profound.

4. Importance for scientific research

[5] Eastman, J.T. & G. Hubold. 1999. The fish fauna of the Ross Sea, Antarctica. Antarc. Sci. 11: 293-304.
[6] Antarctic and Southern Ocean Coalition (2011). The Ross Sea: A Valuable Reference Area to Assess the Effects of Climate Change. ATCM XXXIV IP 92.
[7] See also Ainley, DG. (2010). A history of the exploitation of the Ross Sea, Antarctica. *Polar Record*, 46, pp 233-243 doi:10.1017/S003224740999009X.

The above rationales for a Ross Sea marine reserve comprising the continental shelf and slope underpin the value of the Ross Sea to science and scientific researchers. As the least anthropogenically affected marine region on Earth,[8] the Ross Sea can serve as a natural laboratory for researchers studying not only the effects of climate change and the evolution of marine species, but also the function of ecosystem processes in a relatively undisturbed state.[9] This can greatly enhance our understanding of how ecosystems function and how to minimize human impacts.

Since its discovery, the Ross Sea has been a magnet for scientists, and some data sets begun over 150 years ago have been highly valuable for researchers. Because of its long-term research history it was one of the first areas of the Southern Ocean in which the short-term effects of the El Niño-Southern Oscillation (ENSO) were detected. It was also among the first areas where decadal climate patterns related to the Southern Annular Mode (SAM) were detected in the fauna. Moreover, 400 species and their habitat associations were first described from Ross Sea specimens, an important record as immense numbers of species change their distribution in the face of climate change. Over 100 scientists visit the Ross Sea annually to conduct research on a broad spectrum of topics, from benthic communities to ocean biogeochemistry. It is perhaps the best-studied section of ocean in the Antarctic. Comprehensive protection of the Ross Sea shelf and slope is the best way to ensure that the characteristics that make the region attractive to researchers and valuable to science remain intact.

5. Conclusions

The Ross Sea's scientifically identified characteristics set it apart from even the rest of the Southern Ocean. CCAMLR has recognized its importance by including it in the list of 11 priority areas for the initial network of marine protected areas and marine reserves. Without comprehensive protection of the entire shelf and slope, human activities may change the Ross Sea and degrade these attributes. As a marine reserve, the Ross Sea will provide habitat for vast numbers of ice-obligate species - some found nowhere else -, serve as a reference area for the study of climate change in the Southern Ocean, and provide an unparalleled natural laboratory in which human-induced changes have been minimized.

[8] Halpern, BS, S Walbridge, KA Selkoe, CB Kappel, F Micheli, C D'Agrosa, JF Bruno, KS Casey, C Ebert, HE Fox, R Fujita, D Heinemann, HS Lenihan, EMP. Madin, MT Perry, ER Selig, M Spalding, R Steneck and RWatson. 2008. A global map of human impact on marine ecosystems. Science 319: 948-951.

[9] Antarctic and Southern Ocean Coalition (2010). The Case for Including the Ross Sea Continental Shelf and Slope in a Southern Ocean Network of Marine Protected Areas. CCAMLR XXIX BG 26.

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Appendix 1: Summary of Ross Sea Attributes

Summary of attributes of the Ross Sea, as detailed in CCAMLR 2009, applied to the detailed criteria with which to recognize and preserve special areas under the Madrid Protocol, Convention for Biological Diversity, and designation of World Heritage Sites under UNESCO. Note: as a high seas area, the Ross Sea does not qualify under CBD and WHS/UNESCO but the comparison provides perspective; see also ASOC (2007) and United Kingdom (2007). See Appendix for definitions of numbered criteria under the three respective international agreements.

Madrid Protocol	**CCAMLR**[10]	**CBD**	**World Heritage**	**Special Attribute Justifying Protection**	**How Ross Sea Complies**
I.2.a	X	II.a; II.g	III.a	Uniqueness / rarity; inviolate from human interference; naturalness	Least affected continental shelf/slope on the planet (Halpern et al. 2008; see also Ainley 2009)
I.2.b	X, X	II.b	III.d	Representative example of major marine ecosystem; special importance to life history; important natural habitat	Largest expanse of continental shelf in the Antarctic; a biotic refugium during past glaciations, and likely to be one of the last stretches of ocean having significant amounts of pack ice, year-round, in the foreseeable future. Representative section of the Antarctic Slope Front, first described by Ross Sea studies.
I.2.c		II.c	III.d	Unusual and important assemblage of species	Home to 38% of Adélie penguins, 26% emperor penguins, 30% Antarctic petrels, 6% Antarctic minke whale, ~45% Pacific sector Weddell seals; a rich benthos, comprised of 5 major community types; a benthic biodiversity hotspot (Clarke & Johnston 2003).

[10] CCAMLR criteria are not numbered. Two X marks in one box indicate that there are two different CCAMLR criteria that are represented by the "special attribute" column for that row.

Madrid Protocol	CCAMLR[11]	CBD	World Heritage	Special Attribute Justifying Protection	How Ross Sea Complies
I.2.d		II.a, c, f	III.c	Type locality, endemism; outstanding example on-going biological processes in evolution	Type locality for: one bird, 40 species of fish, and >450 species of benthic animals. 7 species of fish are endemic, and >40 species of invertebrates have so far been found nowhere else; unique genetic strains of Weddell seals, Adélie penguins
I.2.e	X		III.d	Particular interest on-going research; outstanding value point of view of science	Longest hydrologic record in Southern Ocean; 4 longest time series of wild populations (seals, penguins, benthos, toothfish); intensive history of research on climate change at geologic and contemporary time scales; major climate projects ongoing, such as ANDRILL
I.2.f			IIII.b	Outstanding geological, glaciological or geomorphological features	Largest Antarctic continental shelf; largest ice shelf; largest polynya; major contributor to ABW production; active volcano
I.2.g		II. g	III.a	Outstanding aesthetic and wilderness value	Least affected stretch of continental shelf ocean on Earth; pack-ice ecosystem bordered by Antarctica's only major mountain range
I.2.h				Recognized historic value	First-explored part of the high latitude Southern Ocean (Ross) and of Antarctica itself: Ross, Borchgrevink, Amundsen, Scott, Shackleton, Byrd, Hillary; historic huts and other remains from heroic era expeditions
		II.e	III.b	Biological productivity; significant on-going ecological processes	Most productive stretch of the Southern Ocean (Arrigo et al. 1998).
		II.c, d	III.b	Vulnerability, fragility, sensitivity; significant on-going ecological processes	Pack ice ecosystem, likely to soon be one of the few remaining on the planet under current global warming scenarios. Most organisms are slow growing, long lived, thus sensitive to extraction.

[11] CCAMLR criteria are not numbered. Two X marks in one box indicate that there are two different CCAMLR criteria that are represented by the "special attribute" column for that row.

Appendix 2: Distribution of Ross Sea Benthic Communities

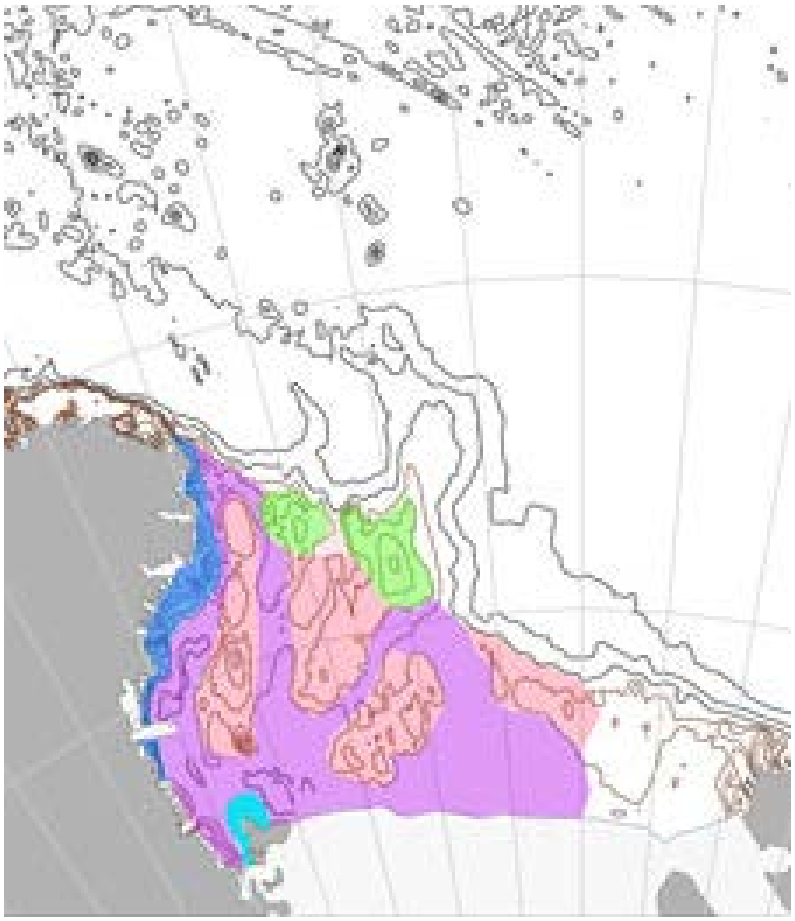

Figure 1. Distribution of Ross Sea benthic communities; green, Pennell Bank; pink, deep shelf mixed; purple, deep shelf mud; blue, Victoria Land coastal; aquamarine, McMurdo Sound. Data from Bullivant (1967) and Barry et al. (2003).

Appendix 3: Conservation Spatial Planning for the Ross Sea

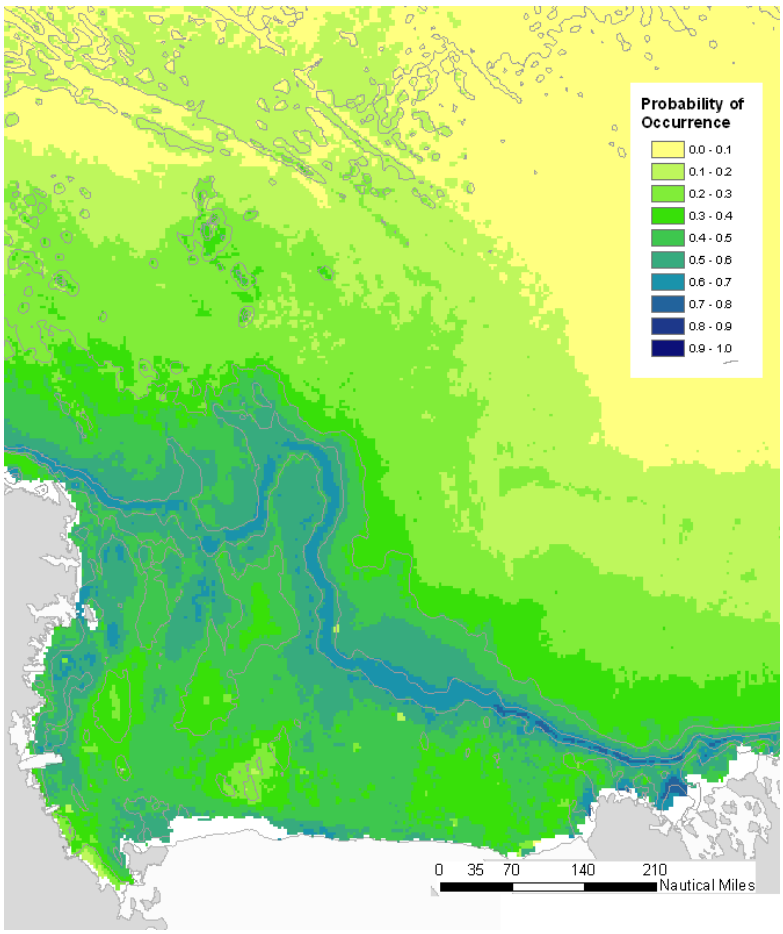

Figure 2. Conservation Spatial Planning for the Ross Sea: Results of a MAXENT model that indicates the probability of occurrence for almost the entire suite of Ross Sea top predators (except Weddell seal): minke and killer whale, crabeater seal, Antarctic toothfish, Adélie penguin, emperor penguin, light-mantled sooty albatross, snow petrel and Antarctic petrel. Data were gathered during a series of oceanographic cruises upon which surveys were conducted, but also including data from CCAMLR (toothfish). Details, including mapping, of individual species' distributions are contained in CCAMLR 2009; details of MAXENT modelling to be submitted to CCAMLR EMM in June 2010. Weddell seals not included because during spring-summer, when ice breaker surveys were conducted, the seals are concentrated at breeding locations within fast ice areas immediate to the shore. Satellite tracking of seals originating from McMurdo Sound, in the SW corner of the Ross Sea, and King Edward VII Land, at the eastern boundary, show that the seals spread out to occupy shelf and slope waters during winter.