



XXXIII Antarctic Treaty Consultative Meeting
3rd to 14th May, 2010

Punta del Este - Uruguay

IP 77

Agenda Item: ATCM 13, CEP
7e
Presented by: ASOC
Original: English

The Case for Inclusion of the Ross Sea Continental Shelf and Slope in a Southern Ocean Network of Marine Reserves

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Abstract

This paper outlines recently assembled information that reinforces the case for protection of the Ross Sea. As noted in ASOC's (2010) paper on Marine Protected Areas (MPAs) for this ATCM, there is now a process in place for the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) to take the necessary steps that - if pursued expeditiously - would enable completion of an initial representative network of marine spatial protection and management by 2012. ASOC encourages Antarctic Treaty Parties via the Committee for Environmental Protection (CEP) to recognise, adopt and engage in this process.

One priority for protection is the Ross Sea continental shelf and slope, an area embedded within one of the regions recognised by CCAMLR and the ATCM/CEP as priority areas for MPA designation. It clearly is of high global importance in terms of its biodiversity, evolutionary significance, disproportional presence of many charismatic high-latitude species, and potential as a climate refuge and reference zone for continued and future change. According to an independent analysis of human impacts on the world's oceans, the Ross Sea is the least affected oceanic ecosystem remaining on Earth (Halpern et al. 2008). It would be the highest latitude habitat represented in a comprehensive and representative network of Southern Ocean MPAs. It has for decades been an area in which investigations have been underway on the interannual, decadal and long-term effects of climate change on the hydrography and biota of a high latitude system.

This paper outlines how the Ross Sea shelf and slope, which are only a part of the "Ross Sea" area identified by SC-CAMLR, fulfills the criteria for selecting sites under the auspices of the Antarctic Treaty and CCAMLR for the designation of marine spatial protection. For perspective, though the statutes do not directly apply to high seas areas (but rather areas under national jurisdiction), this paper makes comparisons with the special area criteria under the Convention for Biological Diversity and UNESCO's World Heritage Sites. The Ross Sea benthos is especially rich and the abundance of its top predator species is unique. Since the shelf and slope contain most of the spawning/breeding, feeding, molting and wintering areas of these predators, ASOC submits that the Ross Sea should be protected as a unit.

I. Background

CCAMLR (2008) has identified 11 areas as priorities for the development of MPAs on the basis of identified high physical heterogeneity, which is indicative of areas of high biodiversity. As noted in ASOC's (2010) paper on Marine Protected Areas (MPAs) for this ATCM, there is now a process in place for the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) to take the necessary steps that - if pursued expeditiously - would enable completion of an initial representative network of marine spatial protection and management by 2012. ASOC encourages Antarctic Treaty Parties via the Committee for Environmental Protection (CEP) to recognise, adopt and engage in this process.

The priority areas are those where most work will initially be focused on the development of a network of MPAs. Bioregionalisation has been endorsed by SC-CAMLR and CEP as a basis for identifying a representative system of MPAs (ATCM 2009). The 2009 designation of the South Orkney MPA by CCAMLR involved the application of a Systematic Conservation Planning process to designate a portion of one of the 11 priority areas, south of the South Orkney Islands. This has become the first MPA in the Southern Ocean (CCAMLR Conservation Measure 91-03). Two of the bioregions identified in CCAMLR's 2007 Southern Ocean Bioregionalisation Workshop are represented within the area designated. Furthermore, two of the 11 priority areas identified by CCAMLR in 2008 are the Northern Ross Sea / Eastern Antarctica and the Ross Sea Shelf. MPAs designated in the Ross Sea region would become the highest latitude areas within the proposed network of Southern Ocean MPAs. This would be complementary and allow comparison with the other lower latitude priority areas such as the South Orkney Marine Protected Area.

On the basis of a Ross Sea workshop held in Fairfax, Virginia in May 2009 as part of the International Marine Conservation Congress (IMCC), CCAMLR's effort to identify likely areas of high biodiversity was further supported by the information presented by the 30 participants. Almost all participants are researchers from the three countries (Italy, New Zealand, and United States of America) that have principally been conducting marine research in the Ross Sea. Included were benthic and pelagic ecologists, oceanographers, as well as sea ice and climate experts. A summary report of the meeting was submitted to the CCAMLR Working Group on Ecosystem Monitoring and Management (CCAMLR 2009).

The report shows how giving full protection to the Ross Sea continental shelf and slope (Figs. 1, 2¹) would:

- Preserve the last remaining near-pristine open-ocean ecosystem on Earth (see summaries in Halpern et al. 2008, Ainley 2009), so that collaborative, international marine science may continue toward understanding oceanic foodweb structure and processes, and responses to climate change, without being confounded by other forms of human activity. Such science has been pre-eminent in this region for five decades, and includes biological research as well as extensive oceanographic, geological and glaciological research (shorter summary of Ross Sea attributes see Smith et al. 2007, 2010). On the basis of its long-term record, Ross Sea data were the first or among the first to indicate the importance of short-term (EL Niño Southern Oscillation - ENSO), decadal (Southern Annular Mode) and longer-term (global climate change) influence on high southern latitude hydrography, sea ice and biota (see discussion in Dayton 1989, Ainley et al. 2005, Jacobs 2006, Stammerjohn et al. 2008).
- Protect exemplary benthic and pelagic biodiversity of high evolutionary significance (e.g., Bradford-Grieve, J. and G. Fenwick 2001, Clarke and Johnston 2003). A portion of the Ross Sea shelf has been a biotic refuge, including an extensive polynya, during glacial maxima, as shown by extensive sediment coring (Anderson 1999, Thatje et al. 2008).
- Protect what according to Intergovernmental Panel on Climate Change (IPCC) models will become a refuge for cryopelagic communities in the face of sea ice disappearance in the remainder of the Southern Ocean possibly within this century (see discussion in Ainley et al. 2010).
- Preserve significant habitat of 32% and 26%, respectively, of the world population of Adélie and emperor penguins (summer, molting, and portion of wintering habitat); 30% of the world population of Antarctic petrels (summer feeding grounds), 6% of Antarctic minke whales (annual feeding grounds) perhaps 50% of Ross Sea killer whales (summer foraging grounds); and approximately 45% of the South Pacific sector Weddell seal population (year round habitat).
- Preserve the primary habitat for sub-adult growth and adult spawning recovery of an ecologically and scientifically important Antarctic toothfish population (Hanchet et al. 2008, Brooks and Ashford 2008).

II. Discussion

Waters overlying the Ross Sea continental shelf and slope comprise ~2.0% of the Southern Ocean (32.9 M km² south of the Antarctic Polar Front² including those beneath ice shelves, an area that is small in size from a global perspective but of enormous importance biologically. As shown by the IMCC Workshop Report (CCAMLR 2009), the biodiversity and other values of the Ross Sea easily fulfill the criteria contained in the Madrid Protocol for establishment of Antarctic Specially Protected/Managed Areas (see also CCAMLR Article II; United Kingdom 2007). Furthermore, although the statutes of the UN Convention for Biological Diversity and UNESCO are not applicable to the high seas of the Southern Ocean, their criteria for identifying Ecologically and Biologically Significant Areas and World Heritage Sites, respectively, are fulfilled by the intrinsic values of the Ross Sea (Table 1). Comparison to the latter agreements, more detailed

¹ Figures 1 and 2 illustrate benthic community distribution and top predator distribution in relation to the Ross Sea shelf and slope.

² See <http://www.fao.org/DOCREP/003/W5911E/w5911e07.htm>.

than those of CCAMLR (see United Kingdom 2007), provides perspective to the global importance of the Ross Sea shelf and slope.

The data and information presented in the IMCC workshop show that the Ross Sea:

- Possesses a fauna, especially its notothenioid fish, that comprises a unique, marine example of an evolutionary radiation on par with those recognized in freshwater and terrestrial World Heritage Sites such as the Galápagos Islands, African Rift Lakes, and Lake Baikal;
- On the basis of projections made from current models in the IPCC array, is likely to be the last stretch of ocean on Earth, perhaps within the current century, that will embrace a cryopelagic community of organisms; and
- Is the best-studied stretch of high latitude, continental shelf ocean in the Southern Hemisphere. These studies include: a) its geologic history, geophysical characteristics, and characterization of its seafloor substrate; b) circulation; c) polynya-facilitated biogeochemical processes leading to extremely high primary production; d) benthic-pelagic coupling whereby water column production enriches the benthic community; e) diverse assemblage of benthic fauna, depending on substrate, slope, current velocities and biological interactions, and varying in age from thousands of years to successional stages of iceberg scour events; and f) paradoxically (in today's world) low level of zooplankton abundance in the context of g) an unusually robust pelagic assemblage of numerous large fish, aerial birds, penguins, pinnipeds and toothed and baleen whales. The latter scenario, i.e. cropping of middle trophic species, thus, leave a significant portion of the phytoplankton ungrazed, therefore constituting what is called, in this case at the large scale, a 'trophic cascade'.

Overall, the Ross Sea foodweb is in similar state as it has been for millennia except for the loss of blue whales (now recovering very slowly) and a decreasing prevalence of large Antarctic toothfish and its predators in recent years (see Devries et al. 2008, Ainley 2009, Ainley et al. 2009, CCAMLR 2009). As a living museum, in which more than 500 species were first described from Ross Sea specimens (type locality, dating back 170 years), the Ross Sea represents a true baseline of species occurrence patterns and habitat associations, which is important in the face of changing ocean climate.

As a natural laboratory, the Ross Sea represents an unparalleled opportunity to continue the concerted efforts of recent years to:

- Investigate climate change and its ecological effects without interference by other, more direct anthropogenic impacts. Indeed, climate change clearly has been altering long-term the sea ice and oceanographic properties of the Ross Sea (Stammerjohn et al. 2008), as well as its biota (Dayton 1989, Ainley et al. 2005, 2010), in a well documented fashion; and
- Investigate the dynamism inherent in both bottom-up and top-down forces that structure this foodweb, rather than mainly the bottom-up processes that now exclusively control the depleted, pyramid-structured, resource-driven marine ecosystems elsewhere. (e.g., Worm et al. 2006, Daskolov et al. 2007, Österblom et al. 2007, Watermeyer et al. 2008a, b).

III. Conclusions

In order to fully understand marine ecosystems, their responses to climate, and ways to keep them healthy, it is important to understand the workings of a fully functional ecosystem that is influenced minimally by direct human factors. For this reason alone, as few such ecosystems remain on Earth (NSF 1998, Halpern et al. 2008), it is essential that the Ross Sea is made a priority for protection. Conferring comprehensive protection to the Ross Sea would not only preserve natural features and offer incomparable aesthetic, wilderness, and spiritual value, but also continue to provide a unique opportunity for science. Finally, the protection of the Ross Sea will allow at least one stretch of open ocean that includes an entire food web to be found somewhere on Planet Earth.

Table 1

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	CCAMLR³	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).

³ 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 ⁴	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			III.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.

⁴ 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.



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).

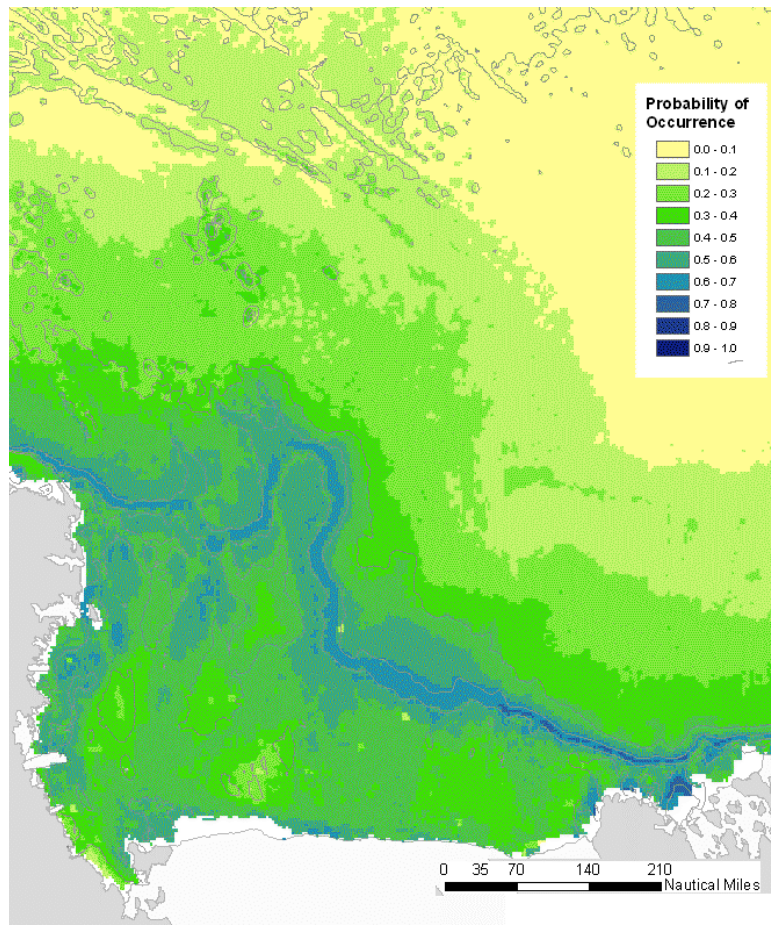


Figure 2. Conservation Spatial Planning for the Ross Sea: Results of a MAXENT model that indicates the probability of occurrence for almost the entire suite of Ross Sea top predators (except Weddell seal): minke and killer whale, crabeater seal, Antarctic toothfish, Adélie penguin, emperor penguin, light-mantled 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.

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V. APPENDIX

I. CCAMLR and the CEP, under their respective treaties and given their particular roles, have different but complementary guidelines, which provide for specially protected status to be accorded marine areas in the Southern Ocean. The attributes under which ASPAs and ASMAs are designated are set out in Annex V, Article 3, of the Madrid Protocol of the Antarctic Treaty (see UK 2009a for a review of designation mechanisms):

1. Any area, including any marine area, may be designated as an Antarctic Specially Protected Area to protect outstanding environmental, scientific, historic, aesthetic or wilderness values, any combination of those values, or ongoing or planned scientific research.
2. Parties shall seek to identify, within a systematic environmental-geographical framework, and to include in the series of Antarctic Specially Protected Areas:
 - (a) areas kept inviolate from human interference so that future comparisons may be possible with localities that have been affected by human activities;
 - (b) representative examples of major terrestrial, including glacial and aquatic, ecosystems and marine ecosystems;
 - (c) areas with important or unusual assemblages of species, including major colonies of breeding native birds or mammals;
 - (d) the type locality or only known habitat of any species;
 - (e) areas of particular interest to on-going or planned scientific research;
 - (f) examples of outstanding geological, glaciological or geomorphological features;
 - (g) areas of outstanding aesthetic and wilderness value;
 - (h) sites or monuments of recognised historic value; and
 - (i) such other areas as may be appropriate to protect the values set out in paragraph 1 above.

Several already-designated ASPAs in the Ross Sea region include small amounts of marine habitat (e.g. Cape Hallett 106, Cape Crozier 124, and Terra Nova Bay 161), as does the Antarctic Pack-ice Seals Agreement under the Antarctic Treaty (Edisto Inlet, Cape Hallett; SW corner of the Ross Sea, including McMurdo Sound), and the recently agreed South Orkneys marine protected area designated by CCAMLR, which protects <1% of the Southern Ocean (CCAMLR Conservation Measure 91-3).

ASPAs are roughly equivalent to IUCN Category I and ASMAs to Category V, according to the 2nd Antarctic Protected Areas Workshop Report 2000.

The guidelines under CCAMLR are highlighted in SC-CAMLR-XXVII (3.55), which registers agreement that the existing benthic and pelagic bioregionalisations developed by the 2007 Bioregionalisation Workshop were adequate, although further refinement may be undertaken; and that a number of methods could be used for designing a representative system of [reserves], including, *inter alia*, bioregionalisation and/or systematic conservation planning. It further mentioned the use of MARXAN as one but not the only software tool, and in the case of the information presented in these paper on the Ross Sea MAXENT is being used (Fig. 2). CCAMLR, in its 2005 marine protected area workshop identified four types of reserves that would suit its spatial protection goals (United States 2005):

- representative areas;
- vulnerable areas;
- scientific areas; and
- areas of noteworthy ecosystem processes

These categories were divided to address further conservation goals that reflected CEP priorities:

- protect unique, rare, highly diverse areas;
- protect critical life-history areas;
- increase resilience to climate change;
- areas kept inviolate from human disturbance; and
- multiple use areas to coordinate activities.

II. While the CCAMLR and CEP work on marine reserves has been progressing, the UN Convention for Biodiversity has begun to consider Biological and Ecological Important Areas, including those on the high seas, which should be protected in perpetuity. This Convention does not specifically apply to the Southern Ocean, owing to its status under the Antarctic Treaty, but the CBD agreed-to criteria for selecting areas are instructive in the present discussion, and reflect Madrid Protocol attributes for ASPAs as well as CCAMLR attributes for spatial protection as enumerated above. These criteria are:

- (a) Uniqueness / rarity;
- (b) Special importance for life history of species;
- (c) Importance for threatened, endangered or declining species / habitats;
- (d) Vulnerability, fragility, sensitivity, or slow recovery;
- (e) Biological productivity;
- (f) Biological diversity; and
- (g) Naturalness.

III. Finally, the United Nations (UNESCO) has developed criteria under which World Heritage Sites can be designated under national jurisdiction, and again these are included within the language of Madrid Protocol attributes for ASPAs. While it is not possible to formally designate such sites under the Antarctic Treaty, owing to the fact that there is no recognized national sovereignty south of 60° S under the Treaty, these criteria are applicable to the Ross Sea. Several areas similar in spatial extent to the Ross Sea (e.g., Lake Baikal, African Rift Lakes) have been designated as World Heritage Sites elsewhere on Earth:

- (a) Superlative natural phenomena or areas of exceptional beauty and aesthetic importance;
- (b) Outstanding examples representing major stages of Earth's history, including the record of life, significant on-going geological processes in the development of landforms, or significant geomorphic or physiographic features;
- (c) Outstanding examples representing significant on-going ecological and biological processes in the evolution and development of terrestrial, fresh water, coastal and marine ecosystems and communities of plants and animals; and
- (d) Important and significant natural habitats for in-site conservation of biological diversity, including those containing threatened species of outstanding universal value from the point of view of science or conservation.