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The Case for Special Protection of the Ross Sea

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The Case for Special Protection of the Ross Sea

Summary

The continental shelf and slope of the Ross Sea is one of the most intensively studied regions in the Antarctic.[1] The Ross Sea, which stretches along the 3000m isobath from Cape Adare, Victoria Land to Cape Colbeck, Marie Byrd Land, is unique, both with regard to its physics and its ecology. Its broad shelf (the most extensive in the Antarctic), extreme seasonality (the region being in complete darkness during winter), numerous significant polynyas, extensive ice shelf (the largest in the world, covering half of the continental shelf), and substantial vertical and horizontal water mass exchanges provide a dynamic environment for a very rich biota, sustained by some of the highest productivity in the Southern Ocean. As much as 25% of Antarctic Bottom Water, destined to flow to all other oceans of the World, is formed in the southern reaches of the shelf to then flow into the abyss beyond. It is the region of the world's oceans least impacted by human activity, and its biodiversity and the evolutionary significance of its biota rivals that of World Heritage Sites such as the Galapagos and Lake Baikal. ASOC re-affirms the case that science needs the Ross Sea to remain free from resource extraction to preserve an unparalleled laboratory to investigate the effects of climate change and other key ecological questions on a largely intact marine biological community.

I. Introduction

CCAMLR and Antarctic Treaty Consultative Parties (ATCPs) have made progress towards the creation of a representative network of Marine Protected Areas (MPAs), Antarctic Specially Protected Areas (ASPAs) and Antarctic Specially Managed Areas (ASMAs) in the Antarctic Treaty area. The first joint meeting of CCAMLR's Scientific Committee and the Committee on Environmental Protection of the Antarctic Treaty System (CEP) in April 2009 endorsed the representative network goal and eleven priority areas, including the Ross Sea, for inclusion in the network. The report from this meeting suggested that both committees develop a strategy to achieve these aims in the next three years and states:

> [It] was recommended that these priority areas be presented to the CEP, and that they consider using these as potential priority areas under the existing framework.[2]

Furthermore, protection for the Ross Sea would be consistent with, and give effect to, the obligations of Article 3 of Annex V to the Environmental Protocol, as well as of Article 3 of the Protocol itself.[3] In addition, the Ross Sea offers an ideal location for conducting the kind of research essential to implementing CCAMLR's ecosystem approach, as it would be a reference area for distinguishing between the effects of harvesting and environmental changes in other CCAMLR areas where commercial fishing would continue to take place.[4]

Previous ASOC papers, and others submitted to CCAMLR and the ATCM have enumerated some rationales for affording special protection to the Ross Sea ecosystem.[5,6] Last year's IUCN World Conservation Congress expressed support for the Ross Sea as a "priority" for protection.[7] A symposium at the International Marine Conservation Congress (IMCC) in May 2009 further elaborated the case, including presenting evidence that the Ross Sea possesses many values as unique as those of the world-famous Galapagos Islands

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[1] Smith, W.O., Jr., D.G. Ainley and R. Cattaneo-Vietti. 2007. Marine ecosystems: the Ross Sea. *Phil. Trans. R. Soc. B* 362: 95–111

[2] France, New Zealand, Russian Federation, United States. 2009. WP 55: Report of the Joint CEP/SC-CAMLR Workshop. ATCM XXXII.

[3] Protocol on Environmental Protection to the Antarctic Treaty (1991).

[4] See Article IX, paragraphs 1(a) and 2(g) of the CCAMLR Convention.

[5] Antarctic and Southern Ocean Coalition. 2008. The Ross Sea: A Candidate for Immediate Inclusion in a Network of Marine Protected Areas. CCAMLR-XXVI/BG/30.

[6] Antarctic and Southern Ocean Coalition. 2009. A Ross Sea MPA: Preservation for Science. ATCM XXXII.

[7] International Union for the Conservation of Nature. 2008. World Conservation Congress Resolution 4.118: Antarctica and the Southern Ocean.

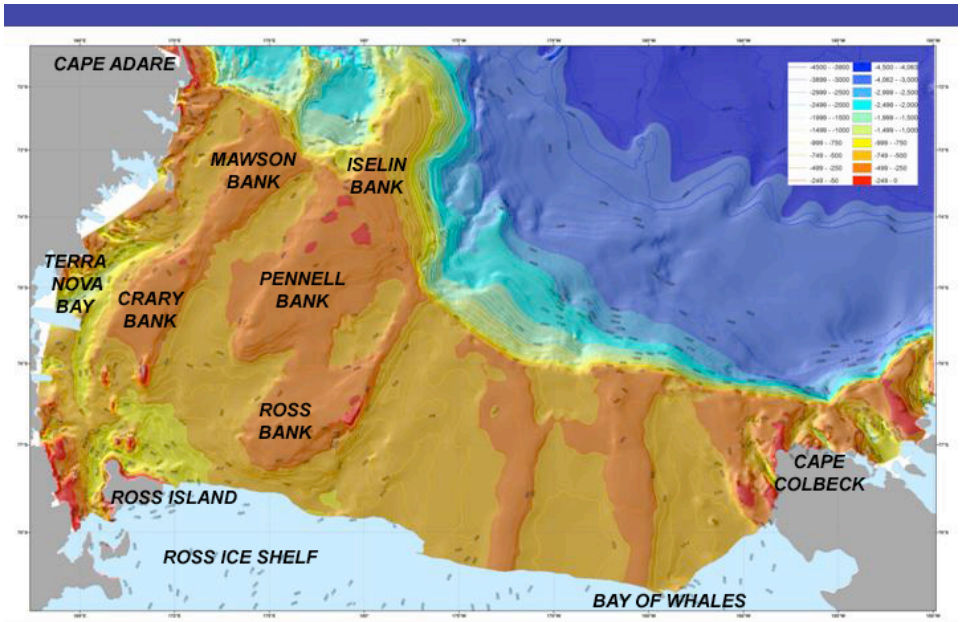
and Lake Baikal.[8] With its documented scientific values, outstanding evolutionary history, magnificent scenery, and habitats for a broad and unusually abundant array of Antarctic species, the Ross Sea deserves both international recognition and special protection.

This paper highlights the principal reasons for giving special protection to the Ross Sea using the tools possessed by CCAMLR and the Environmental Protocol. The Ross Sea is of immense value to scientific research. As ASOC has previously noted, it "is the last open-ocean, cold-water, continental shelf (neritic) ecosystem remaining on Earth whose foodweb has yet to be seriously and irretrievably altered by direct human activities."[9] Unlike other areas in the Antarctic and sub-Antarctic, its whale, seal and demersal fish populations were not significantly depleted by hunting,[10] and commercial fishing has only begun recently within its confines and vicinity.

A recent study by Halpern et al. (2009) scored regions of the global ocean according to the extent of human impacts as measured by 17 factors. The Ross Sea received the lowest score - 0.1 - of all 232 regions surveyed, compared to scores of 17.0 or higher for more heavily impacted regions.[11] Yet this lightly-touched region will most certainly be changed in adverse and undetectable ways if the toothfish fishery continues without better information on the size and productivity of the stock and its numerical and functional relationships with other components of the Ross Sea ecosystem. As documented in other ocean regions, depletion of top predators such as the Antarctic toothfish affects the numerical and functional relationships of other ecosystem components, and illustrates how the fishery will affect the value of the Ross Sea as a natural laboratory.[12]

II. Background

When ASOC speaks about the "Ross Sea" we mean the entire Ross Sea shelf and slope, as described above.



[8] Those entities have been given international recognition as World Heritage Sites by UNESCO.
[9] Ibid, 3.
[10] The Blue Whale population, however, was decimated.
[11] Halpern, S., et al. 2009. A Global Map of Human Impact on Marine Ecosystems. *Science* 319: 948-952.
[12] Heithaus, M. R., A. Frid, A.J. Wirsing and B. Worm. 2008. Predicting ecological consequences of marine top predator declines. *Trends in Ecology & Evolution* 23: 202-210; Baum, J.K. and B Worm. 2009. Cascading top-down effects of changing oceanic predator abundances. *Journal of Animal Ecology* 78: 699-714: a detailed review containing many examples; see also CCAMLR WG-EMM-04-20, WG-EMM-06-07.

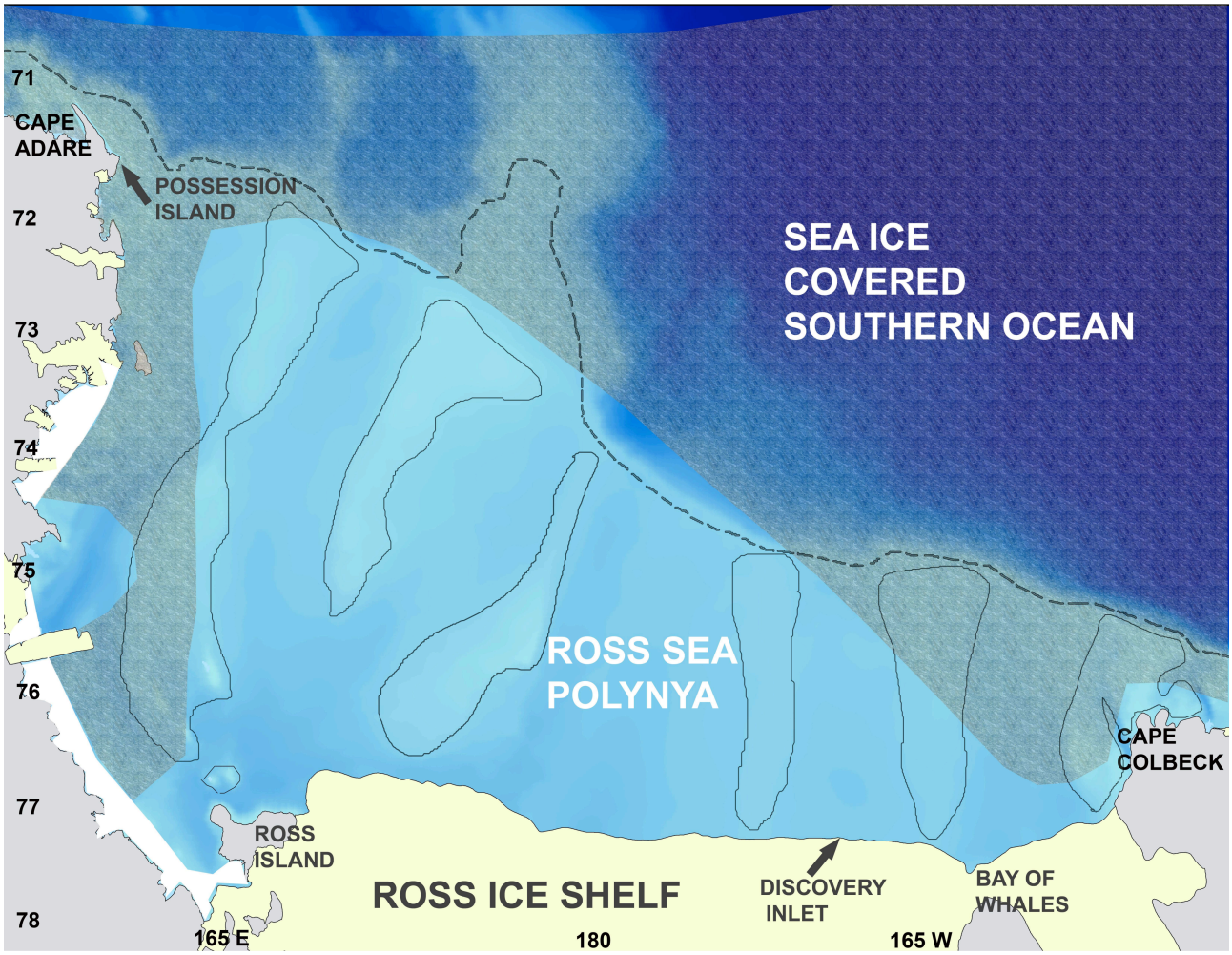


Figure 1. Top panel, the most up-to-date detailed bathymetry of the Ross Sea. Bottom panel shows the usual distribution of sea ice during spring. The shelf-break, defined as the 800 m isobath, shown by a dashed line (slope extends down to the 3000m isobath shown by shading); sea ice shown as marbled shading in a distribution typical of early December. Discovery Inlet, an embayment in the Ross Ice Shelf that was similar to Bay of Whales, is no longer a feature, having been the product of iceberg calving in the early years of the 21st century.

A. Essential Habitat

As elaborated in a previous CCAMLR paper,[13] the Ross Sea shelf and slope encompass less than 13% of the circumference of Antarctica, and by area only 3.2% of the Southern Ocean, but has unusually large populations of many Antarctic species that otherwise are distributed more or less evenly around the remainder of the continent or not at all (for example, the lack of penguin colonies in all but the very northern coasts of the Weddell Sea). It supports an estimated:

- 38% of the world population of Adélie penguins
- 26% of the world population of Emperor penguins
- 30% or more of the world population of Antarctic Petrels
- 6% of the world population of Antarctic Minke whales
- 45% of the Southern Ocean Pacific Sector population of Weddell seals.

Moreover, the Ross Sea ranks as an Antarctic biodiversity hotspot due to the richness of its benthic invertebrate fauna, its thousands of species and its numerous species of ancient lineage.[14]

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[13] ASOC 2008, 2.

[14] Bradford-Grieve, J. and G. Fenwick. 2001. *A Review of the Current Knowledge Describing the Biodiversity of the Ross Sea Region*. Final Research Report for Ministry of Fisheries Research Project ZBD2000/01, Wellington; Clarke,

The Ross Sea constitutes particularly important habitat for a variety of species. Global warming and other human impacts may render other locations where these species live increasingly unsuitable, and the Ross Sea may become their refuge. Additionally, as detailed below, sea ice extent is projected to continue to increase in the Ross Sea region for at least the next few decades, even as it declines in other areas of the Antarctic.[15] Loss of sea ice has been shown to adversely impact the populations of many Antarctic species, including Antarctic krill and Adélie and emperor penguins. Krill, the forage-base of the Antarctic foodweb in pelagic and slope waters, is critical for the survival of many upper-level species. Declines in krill biomass will continue to have widespread negative impacts. The impact of ocean acidification is also predicted to affect extreme latitudes first with shelled species like pteropods particularly at risk.[16] Investigating such a change in an otherwise unaltered ecosystem is critical.

B. Evolutionary Significance

A growing body of evidence indicates that the Ross Sea is a site whose evolutionary significance rivals that of World Heritage Sites such as the Galapagos and Lake Baikal. Although the Ross Sea lacks the high number of species found in those places, which is a typical characteristic of high latitude biotas, its level of diversity is higher than that of many other polar areas,[17] and thus it is of great interest to science.

Antarctica generally, and the Ross Sea specifically, is an ideal location for studying the evolution of marine species and for determining the biological effects of climate change (see below). Its geologic history is among the best known of the continents, and it is separated from other Southern Hemisphere shelf areas.[18] The seas around Antarctica, and the Ross Sea in particular, have an unusually large number of endemic species as a result.[19] The Ross Sea has experienced periods of isolation from the rest of the continental shelves, making it even more useful for researching the radiation and adaptation of species. The evolution of Antarctic notothenioids, or icefish, has been identified as a unique evolutionary case study.[20] Notothenioids are highly prevalent in the Ross Sea and research in the Ross Sea pioneered understanding of their eco-physiological adaptations, thus the region should continue to make an especially useful contribution to scientific understanding of their evolution and uniqueness.

The Ross Sea fish fauna is dominated by notothenioids, which constitute a majority of species diversity (76.6%), abundance (91.6%) and biomass (91.2%).[21] According to Eastman and Ainley (2009), "[t]his level of species dominance by a single taxonomic group is unique among piscine shelf faunas of the world."[22] This suborder has long fascinated researchers because although its species lack a swim bladder, they inhabit many levels of the water column. Some species have attained neutral buoyancy primarily through reduced mineralization of their skeleton and increased fatty deposits. Notothenioids also produce an anti-freeze glycoprotein that enables them to tolerate cold Antarctic waters.[23]

Current notothenioid species radiated from a common lineage after other Late Eocene fauna went extinct as the climate cooled, with the 5 major lineages appearing approximately 25 million years ago. They subsequently evolved from a primarily benthic order to one with epibenthic, semipelagic, cryopelagic, and pelagic species. Additionally, some notothenioids may constitute a "species flock", recently evolved, and if

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A. and N.M. Johnston. 2003. Antarctic marine benthic diversity. *Oceanography and Marine Biology: an Annual Review* 41: 47–114. See also Section IV, below.

[15] Ainley, D.G., J. Russell et al. 2009. Antarctic penguin response to habitat change as earth's troposphere reaches 2°c above pre-industrial levels. *Ecology*, in press.

[16] Orr, J.C. et al. 2005. Anthropogenic ocean acidification over the twenty-first century and its impact on calcifying organisms. *Nature* 437: 681-686.

[17] Eastman, J.T. and G. Hubold. 1999. The fish fauna of the Ross Sea, Antarctica. *Antarctic Science,* 11:293-304.

[18] Clark and Johnston 2003.

[19] Eastman, J.T. and D.G. Ainley 2009. The Ross Sea as a Unique Evolutionary Site. CCAMLR WG-EMM paper, 4.

[20] Ibid.

[21] Ibid, 4.

[22] Ibid, 4.

[23] Eastman, J.T. (1993). *Antarctic Fish Biology*. San Diego: Academic Press.

so would be the only one known among marine fish. Seven species of notothenioids, mainly within that species flock, are endemic to the Ross Sea, a high number for an area of its relatively small size.[24]

The Ross Sea offers other significant examples of radiation, particularly among invertebrates such as bryozoans, pycnogonids, echinoderms, amphipods and isopods.[25] New species are being discovered faster than they can be catalogued. As indicated in the review by Clarke and Johnston (2003), the Ross Sea is one of the Southern Ocean biodiversity hotspots among invertebrate animals.[26] More than 400 Southern Ocean species were first described from Ross Sea specimens. Among vertebrates, lobodontine seals and killer whales are other examples of radiation likely involving the Ross Sea. However, because the radiations of these species occurred in a marine environment, they are of as much interest to evolutionary biology as more well-known terrestrial examples such as Galapagos finches. These characteristics mean that Ross Sea is a "cold evolutionary hotspot."[27]

C. A Uniquely Intact Ecosystem

As noted earlier, the recent study by Halpern et al. (2009) identified the Ross Sea as the region of the world's oceans least impacted by human activity.[28]

Although whaling and limited sealing both took place in the Ross Sea and commercial fishing has developed since 1997, the Ross Sea ecosystem recovered to now be relatively intact. Since fur seals and elephant seals, the primary species hunted by commercial sealers, do not live to any appreciable degree in the Ross Sea, the smaller-scale seal hunting that did take place had a mostly local effect. Some research expeditions killed Weddell seals in the vicinity of McMurdo Sound and the Bay of Whales for food, and later national research programs did as well, but this practice ceased in 1985.[29] It is estimated that the original McMurdo Sound Weddell seal population numbered around 3,000. It since has stabilized at about 2,000, with the difference attributed to changes in "an ocean regime shift in the mid-1970s and related changes of sea ice or the foodweb."[30]

The small number of elephant seals (on the order of a few dozen) in the summer molting and foraging populations have mostly disappeared from the Ross Sea, most likely because the source population on Macquarie Island and other New Zealand sub-Antarctic islands has shrunk as prey populations have decreased in waters around these islands.[31] Therefore, very few seals can be considered missing from the original Ross Sea ecosystem.

Whaling in the Ross Sea was not as limited as sealing, but still has not had as extensive an impact on the Ross Sea ecosystem as it did in other parts of the Southern Ocean. Hunting for blue and fin whales during the 1920s, which resulted in the taking of the largest blue whales ever seen, was largely confined to the continental slope.[32] Thousands of minke whales were removed during the 1970s and early 1980s from IWC Area V and VI (which include the Ross Sea), but numbers in the Ross Sea have since rebounded.[33] There is no evidence that populations of killer whales and Arnoux's beaked whales have declined over the past century.[34] Blue whales worldwide have proven extremely slow to recover from whaling, but it is hoped that

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[24] J.T. Eastman, personal communication.
[25] Ibid, 6.
[26] Clarke, A. and N.M. Johnston. 2003. Antarctic marine benthic biodiversity. *Oceanography and Marine Biology: an Annual Review* 41: 47–114
[27] Eastman, J. (2009). The Nature of High Antarctic Marine Biodiverstiy: the Ross Sea as a Unique Evolutionary Site. Presentation at IMCC 2009. In Ainley and Weller 2009.
[28] Halpern, S., et al. 2009. A Global Map of Human Impact on Marine Ecosystems. *Science* 319: 948-952.
[29] ASOC 2009, 5.
[30] ASOC 2009, 5.
[31] ASOC 2009, 5.
[32] ASOC 2009, 5-6.
[33] Ainley, D.G. 2009. A history of the exploitation of the Ross Sea, Antarctica. *Polar Record* Published online by Cambridge University Press doi:10.1017/S003224740999009X.
[34] Ibid.

with conservation, more whales will increasingly augment recent sightings in the Ross Sea, and elsewhere.[35]

Another source of major ecosystem alteration, commercial fishing for Antarctic toothfish, commenced during the past 12 years.[36] Nevertheless, fishing pressure in the Ross Sea is substantial and has the potential to permanently change the foodweb through direct and indirect impacts[12]. Research indicates that the foraging grounds for Weddell seals, killer whales, Arnoux's beaked whales and penguins overlap with those of the current toothfish fishery.[37,38] Weddell seals and likely type-C killer whales prey on toothfish, and Arnoux's beaked whales likely prey on the benthic species caught in large numbers as by-catch in the fisheries.[39] These species, including penguins, will be affected indirectly as fishing changes the structure of the foodweb.[40] As summarized in the papers cited in footnote 12, removing top predators has caused dramatic changes in benthic invertebrate communities, despite the fact that the top predators do not forage on the invertebrates, and has facilitated the invasion of alien and gelatinous species to several marine ecosystems.

III. Climate Reference Zone

The Ross Sea region has received intense interest from climate scientists because it is one axis of the "Antarctic Dipole" or "Southern Annular Mode" comprised of two stationary low pressure systems, one over the Ross-Amundsen and the other over the Weddell regions, whose strength oscillates in a complementary fashion.[41] The oscillation has become stuck in its current "positive" mode, with warm, on-continent winds over the Antarctic Peninsula, but cold off-continent winds over the Ross Sea region. This ultimately occurs because of global warming and the Antarctic Ozone Hole.[42] Though aware of the melting of sea ice and the warming of the Antarctic Peninsula, the public is less aware of the fact that sea ice has been growing in the Ross Sea region. Climate and marine scientists, however, have been studying this phenomenon. In part, this interest is based on the 100 years of observations on weather and climate, and the incredible archive of information from ice- and sediment-cores, as well as oceanographic investigation, that have come from the Ross Sea region - a dataset unavailable in its extent for any other location in the Antarctic.[43]

The results of recent climate modeling indicate that as the global atmospheric temperature rises, in conjunction with effects from the Antarctic Ozone Hole, the ocean climate of Antarctica and the Ross Sea region will continue to change.[44] Though the Ross Sea has and will continue to experience the effects of climate change, including a decrease in ice thickness and increased snowfall, negative effects on overall sea ice coverage will not be as severe as those in other locations in the Southern Ocean in the medium term. Thus it is expected that "the Ross Sea could well be one of the last places on Earth in which a sea ice

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[35] ASOC 2009, 6; Recent Sightings of Blue Whales in the Ross Sea: Matsuoka, K., T. Hakamada, H. Kiwada, H. Murase, and S. Nishiwaki. 2008. *Distributions and standardized abundance estimates for humpback, fin and blue whales in the Antarctic Areas IIIE, IV, V and VIW (35◦E -145◦W), south of 60◦S*. Cambridge, UK: International Whaling Commission (paper SC/D06/J7); Sala, A., M. Azzali, A. Russo, A. De Felice and A. Lucchetti. 2008. Results of a survey on krill, environment and predators in CCAMLR division 88.1 in the Austral summer 2003-2004. GLOBEC Newsletter April 2008.

[36] ASOC 2009, 5. This was established as an "exploratory" fishery, and remains in that category today.

[37] Siniff, D., R. Garrott, and J. Rotella. 2009. The Ross Sea and the Pack Ice Seals. Presentation at IMCC 2009. In Ainley and Weller 2009.

[38] DeVries, A. and Eastman, J. 2009. The Antarctic Toothfish. Presentation at IMCC 2009. In Ainley and Weller 2009.

[39] Ainley and Weller 2009.

[40] Olmastroni, S. and D Ainley. 2009. Seabirds of the Ross Sea. Presentation at IMCC 2009.

[41] Stammerjohn, S.E., D.G. Martinson, R.C. Smith, X. Yuan and D. Rind. 2008. Trends in Antarctic annual sea ice retreat and advance and their relation to El Niño–Southern Oscillation and Southern Annular Mode variability. *Journal of Geophysical Research* 113: 1-20.

[42] Thompson, D.W.J. and S. Solomon. 2002. Interpretation of recent Southern Hemisphere climate change. *Science* 296: 895-899.

[43] For example, see http://www.andrill.org/.

[44] Russell, J. 2009. The Future of the Ross Sea: Circulation, Carbon and Climate. Presentation at the International Marine Conservation Congress 2009. In Ainley and Weller 2009.

ecosystem persists."[45]

Sea ice is critically important to many Antarctic species. Thus, the distributions, abundance, productivity, and ecological relationships of at least some of these species can be expected to change as sea ice and other characteristics of the Southern Ocean change in response to global warming. Because the Ross Sea has been less affected by commercial fisheries, whaling and other human activities than other seasonally ice covered marine areas, it provides a unique potential for documenting the biological as well as the physical and chemical effects of global warming on a polar marine ecosystem.

The effect of ocean acidification caused by elevated carbon dioxide levels is predicted to affect the cold Southern Ocean species first. As noted in a recent paper, "the ability of marine animals, most importantly pteropod molluscs, foraminifera, and some benthic invertebrates, to produce calcareous skeletal structures is directly affected by seawater CO_2 chemistry."[46] High latitude colder seawater has lower levels of carbonate concentration necessary for calcium carbonate skeletons, the concentration further declines as the pH drops to a point where skeletons start to dissolve. Species like pteropods, which are estimated to make a quarter of the Ross Sea zooplankton biomass will be among the first affected,[47] with pteropods being important to fish in the Ross Sea foodweb.[48]

However, it will be difficult if not impossible to differentiate the biological effects of global climate change from those of fishing, whaling, and other human activities, unless those activities are limited pending (a) acquisition of more reliable knowledge of the distributions, abundance, productivity, and role of top predators in structuring the Ross Sea food web(s), and (b) development of monitoring programs capable of detecting and determining the cause or causes of changes in the food web(s). Such limitations can best be accomplished by providing special protection to the Ross Sea using the tools provided by CCAMLR and the Environmental Protocol, and developing and instituting a management plan for meeting the science goals.[49]

IV. Research Importance

The Ross Sea ecosystem, which is near pristine in regard to direct human impacts, offers an unmatched opportunity for researchers to study an almost intact open ocean marine ecosystem, providing insights into what might be expected as attempts are made to repair damaged marine ecosystems elsewhere.[50]

The Ross Sea boasts the longest history of scientific research in the Southern Ocean, with records starting 170 years ago. There are fifty years of continuous records of marine hydrography, Weddell seal demographics, Adélie and emperor penguin population change, changes in benthic communities and variation in prevalence of Antarctic toothfish. Well over 1000 published papers detail the ecology of this system.

The Ross Sea is the type locality for 40 species of Antarctic fish and more than 400 species of multicellular invertebrates, as well as that of the iconic South Polar Skua. It therefore constitutes a world-class "living museum" and venue to understand climate-related faunal replacements, species evolution and adaptation. If afforded appropriate protection it will continue to be a world-class laboratory, which can be used to gauge the effects of climate change on marine ecosystems in general and those of the Antarctic specifically. In addition, the breadth of its shelf allows clarification of the roles of shelf versus deep-water biophysical and

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[45] Ainley, D. and J. Weller 2009. The Ross Sea, Antarctica: Science, Policy and the Public in a Pristine Marine Ecosystem. International Marine Conservation Congress Workshop Proceedings Preliminary Report. Available at http://www.asoc.org/AntarcticAdvocacy/CampaignstoProtectAntarctica/ProtectingtheRossSea/tabid/140/Default.aspx.

[46] Fabry, V. J., B. A. Seibel., R. A. Feely,, and J.C. Orr. (2008). Impacts of ocean acidification on marine fauna and ecosystem processes. *ICES Journal of Marine Science* 65: 414–432.

[47] McNeil, B. I. and R. J. Matear. 2008. Southern Ocean acidification: A tipping point at 450-ppm atmospheric CO2. *PNAS* 105(48): 18860–18864.

[48] Smith, W.O., Jr., D.G. Ainley & R. Cattaneo-Vietti. 2007. Marine ecosystems: the Ross Sea. *Phil. Trans. R. Soc. B* 362: 95–111.

[49] ASOC 2009, 3.

[50] Kim, S., S. Thrush, M. Chiantore, M. Vacchi, and J. Barry. 2009. Ross Sea: Benthic-Pelagic Coupling. Presentation at IMCC.

community processes that are often incomprehensibly mixed on the narrow shelves that surround the rest of Antarctica.

V. Concluding Remarks

ASOC submits that preservation of the Ross Sea ecosystem constitutes an imperative for CCAMLR and the Antarctic Treaty Consultative Parties. Unless the Antarctic Treaty System works in a coordinated fashion to provide appropriate protective status, using the tools available in CCAMLR and the Environmental Protocol, the result will be a great loss to science, to the region's wildlife, and to the world community as a whole. Meeting the international goal of 2012[51] for establishing a representative system of protected areas in the Southern Ocean that includes the Ross Sea is achievable if concerted action is taken in the two Antarctic Treaty System fora over the next three years, ideally including some intersessional work.

Affording protection to the Ross Sea would serve the interests and objectives of the two instruments under whose aegis the action would be taken - the Antarctic Treaty (through the Environmental Protocol) and CCAMLR. With respect to the Treaty, special protection status for the Ross Sea would be consistent with and give effect to the obligations of Article 3 of Annex V to the Environmental Protocol, as well as Article 3 of the Protocol.

Similarly, protection of the Ross Sea would serve the interests of CCAMLR itself by providing an unequalled area for undertaking the kind of baseline research essential to implementing CCAMLR's ecosystem approach.[52] It would also provide a reference area for distinguishing between the effects of harvesting and environmental change in other areas of CCAMLR where fishing is taking place. This obviously will be increasingly important in light of accelerated climate-driven changes.

[51] The World Summit on Sustainable Development (2002) and the World Parks Congress (2003) set slightly different but similar goals for having a representative network of MPAs by 2012: http://www.protectplanetocean.org/collections/introduction/introbox/targets/story.html for details.
[52] See Article IX, paragraph 1 (a) and Article IX, paragraph 2(g).