The Antarctic and Climate Change

Information Paper
Submitted by ASOC to XXX ATCM
(CEP Agenda Item 3, ATCM Agenda Item 13)

1. Introduction

Being the largest areas covered in snow and ice on Earth, the Antarctic and the Arctic are extremely important to the balance of the global climate, and remarkably vulnerable to global climate change. It has become a truism to say that scientific research carried out in the Antarctic provides crucial information about the impacts of human activities in fueling global climate change. Year by year as that scientific evidence becomes more compelling, and when added to similar findings from the Arctic and other places around the globe, the need for a paradigm shift away from our present carbon-based energy system becomes manifest.

As one of the most sensitive 'canaries in the coal mine' globally, some parts of the Antarctic are melting and eroding much more quickly than predicted, and in some remarkable ways. Temperatures along the Antarctic Peninsula have risen as fast as anywhere on earth over the past few decades. These rapid changes are impacting on the marine ecosystem along the west coast of the northern Antarctic Peninsula. It is possible changes here, though confused by profound changes in the foodweb owing to whale depletion and over fishing, could foreshadow changes in the future for other parts of the ocean south of the Polar Front, but the time frame for these wider changes is anything but clear. It is fitting that the International Polar Year (2007-2008) has commenced a two-year research program in the Antarctic and Arctic. The work accomplished should further our understanding of the complex interactions of polar climate with the ecosystem.

This Information Paper provides an updated overview of Antarctic climate change research from 2004 to the present, building on our Information Paper on Climate Change at the last ATCM.[1] ASOC hopes it is useful in informing ATCM delegates, the public and decision-makers around the world about these research findings and their implications.

The Fourth Assessment Report of Working Group 1 of the Intergovernmental Panel on Climate Change (IPCC), published on February 2, 2007, presents an overwhelming case for climate change being human-induced. *Science* reported it this way:

> They've said it before, but this time climate scientists are saying it with feeling: The world is warming; it's not all natural, it's us; and if nothing is done, it will get a whole lot worse.[2]

The IPCC presents strong and persuasive scientific evidence showing that most of the change in global climate in the past 50 years can be attributed to human activities, predominantly from burning fossil fuels and the consequent release of greenhouse gases into the atmosphere. The Panel paints an exceedingly bleak future should our governments not take the lead and act on the information:

> Global atmospheric concentrations of carbon dioxide, methane and nitrous oxide have increased markedly as a result of human activities since 1750 and now far exceed pre-industrial values determined from ice cores spanning many thousands of years. The global increases in carbon dioxide concentration are due primarily to fossil fuel use and land-use change, while those of methane and nitrous oxide are primarily due to agriculture.[3]

ASOC urges this ATCM to take some immediate steps to develop a plan for human activity in Antarctica ultimately to be carbon neutral. Such steps could include, for example:

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[1] The Antarctic and Climate Change, IP 62: http://www.asoc.org/pdfs/2006/Climate%20Change%20IP.pdf
[2] *Science*, 315(5813) (9 February 2007), 754-757.
[3] Summary for Policy Makers, p. 1: http://www.ipcc.ch/SPM2feb07.pdf

- setting significant targets to reduce use of fossil fuels;
- actively exploring solar and wind alternatives;
- setting up an emissions inventory of all greenhouse gas sources in the region – including vessels and aircraft (both commercial and governmental);
- establishing a program to offset irreducible emissions from stations, vessels and aircraft of all types and provenance coming to and utilizing the Antarctic; and
- urging CCAMLR to ensure that exploitation of krill and other living marine resources of the Southern Ocean does not adversely impact the capacity of the region to serve as a carbon sink.

Using Antarctica as a 'clear mirror' the Parties could issue a call, based upon their duty of care for the Antarctic and their knowledge of Antarctic science and environment, to those working in other international fora to act with urgency in seeking reductions in greenhouse gas emissions to a "safe" level. ASOC proposes that climate change should be on the annual ATCM agenda each year, and that the ATCM should request the CEP to focus more attention on the implications for the Antarctic environment and to report advice back to the ATCM. Looking ahead, the Parties should consider capping and reducing fossil-fuel derived energy use in the Antarctic Treaty Area.

2. Overview

Antarctica is composed of two geologically distinct regions, East Antarctica and West Antarctica, separated by the Transantarctic Mountains. Together the West and East Antarctic ice sheets constitute Earth's largest reservoir of fresh water. The presence of these massive ice sheets and the polar location make Antarctica a powerful heat sink that strongly affects the climate of the whole Earth. The white surface of snow and ice reflect 90% of the sun's radiation. The annual sea-ice cover around the continent, which in winter reaches an area greater than that of the continent itself, seasonally modulates exchanges of heat, moisture and gases between the atmosphere and ocean. As the sea ice forms each winter, the salt it rejects sinks to the sea floor to form cold, dense, oxygen-rich Antarctic Bottom Water that flows north under the world's oceans, contributing significantly to the "ocean conveyor" and ventilating deep-sea life.

The Antarctic ice sheets contain sufficient ice to raise world-wide sea level by more than 60 meters if melted completely. The most immediate threat to the inhabited world comes from the melting of the West Antarctic ice sheet (WAIS), which is a marine-based ice sheet that rests on a bed far below sea level and has the potential for rapid shrinkage. Based on the latest evidence, the WAIS is thought by some in the scientific community to be capable of catastrophic disintegration due to global warming, which could raise sea levels by 5 meters in a few centuries. That would inundate large portions of the world's low-lying countries and coastal cities.[4] It appears to be losing mass now at a rate that contributes a significant portion of current global sea level rise.[5] The East Antarctic ice sheet, on the other hand, which is independent and not seabed gounded, appears to be thickening slightly, but this is not enough to offset losses from West Antarctica.[6] The fact that rates of discharge from some Antarctic ice streams draining WAIS have increased markedly since the 1990's[7] suggests that the mass balance may also be rapidly changing.

Winter temperatures over the Antarctic continent, and principally in West Antarctica, as well as the Southern Ocean, have risen by more than 2°C in the past 30 years. Warming also in the middle troposphere (the layer of the atmosphere at 5 km above ground) over the Antarctic is the largest regional warming on Earth at this

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[4] Bindschadler, R.A., and C.R. Bentley. 2002. On thin ice? *Scientific American*, December), 66-73.

[5] Velicogna, I. & Wahr J., 2006. Measurements of Time-Variable Gravity Show Mass Loss in Antarctica, *Science*, 311,1754-1756.

[6] Zwally, H.J., M.B. Giovinetto, J. Li, H.G. Cornejo, M.A. Beckley, A.C. Brenner, J.L. Saba, D. Yi. 2005. Mass changes of the Greenland and Antarctic ice sheets and shelves and contributions to sea-level rise: 1992–2002. Journal of Glaciology, Vol. 51, No. 175, 509-527

[7] Thomas, R.H., E. Rignot, G. Casassa, P. Kanagaratnam, C. Acuña, T. Akins, H. Brecher, E. Frederick, P. Gogineni, W. Krabill, S. Manizade, H. Ramamoorthy, A. Rivera, R. Russell, J. Sonntag, R. Swift, J. Yungel, and J. Zwally. 2004. Accelerated sea-level rise from West Antarctica. Science, 306, 255-258; DOI: 10.1126/science.1099650.

level[8]. In particular, the northerly region of the Antarctic Peninsula has experienced rapid warming over the last 50 years and glaciers are shrinking rapidly. In one study on trends in 244 marine glacier fronts on the Antarctic Peninsula and associated islands over the past 61 years, 87% were shown to have retreated, and a clear boundary between mean advance and retreat has migrated progressively southward.[9] The complete disintegration of Antarctic Peninsula glaciers would raise sea level by about 0.5 meter.

Oppenheimer and Alley, writing on WAIS and climate policy in the journal "Climate Change" state: "Disintegration of the West Antarctic ice sheet (WAIS) has long served as a benchmark of dangerous climate change. Recent findings with implications for the future of the WAIS are of importance to policy makers and others grappling with the meaning of Article 2 of the U.N Framework Convention on Climate Change and its injunction to avoid 'dangerous anthropogenic interference with the climate system.' These observations show acceleration of glaciers coupled to abrupt ice-shelf disintegration along the northern and western Antarctic Peninsula. The key issue is whether the main body of the WAIS would behave similarly if its ice shelves were thinned or removed by a warming climate."[10]

The expectation now is that loss of buttressing ice shelves through warming of Circumpolar Deep Water, which is increasing basal melting, will lead to faster flow of the ice into the ocean. Although atmospheric warming and reduction in sea-ice cover almost surely will continue to give rise to increased evaporation over the ocean and increased snowfall on the continent, thereby tending to lower sea level, this cycle tendency will be reduced in frequency and then go negative as temperatures rise further. Reductions in sea-ice cover will have significant impacts on ice-dependent species, such as whales, penguins, seals and krill, as well as far-reaching consequences on the global ocean circulation. Reduction will also increase access for biotic (fishing) extraction. The absorption by the ocean of increasing CO_2 emissions is also leading to increasing acidification of the oceans, principally in the polar regions, with repercussions to organisms that use calcium carbonate for their internal or external skeletons.

3. Recent Scientific Research Results

The most recent scientific results, particularly when added to the stream of research emanating from the Antarctic in recent years, make for disturbing reading.

3.1 Ice Cores

Ice cores from the Antarctic continent have provided one of the key pieces of information in understanding humans' role in global climate change. Ice cores from Vostok and Dome C reveal that today's concentration of greenhouse gases in the atmosphere has not been exceeded during the past 650,000 years[11] and likely not during the past 20 million years.[12] They show that the rate of increase of greenhouse gases in the atmosphere over the past century is unprecedented, at least during the past 20,000 years. Using these data, researchers have found a close correlation between global temperature and greenhouse gas concentrations in the atmosphere over the past 420,000 years,[13] supporting the link between human use of fossil fuels and global climate change. This is already evident from isotopic measurements showing a significant fossil fuel imprint on carbon in the earth's atmosphere.

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[8] Turner, J., Lachlan-Cope, T.A., Colwell, S., Marshall, G.J., Connolley, M. 2006. Significant Warming of the Antarctic Winter Troposphere. Science 311 (5769), 1914-1917.

[9] Cook, A.J., A. J. Fox, D. G. Vaughan, J. G. Ferrigno. 2005. Retreating glacier fronts on the Antarctic Peninsula over the past half-century. Science, Vol 308, 541-544.

[10] Oppenheimer, M., and R.B. Alley. 2004. The West Antarctic Ice Sheet and Long Term Climate Policy. *Climatic Change*, 64(1-2), 1-10.

[11] Spahni, R., Chappellaz, J., Stocker, T.F. et al. 2005. Atmospheric Methane and Nitrous Oxide of the Late Pleistocene from Antarctic Ice Cores. *Science*, 310, 1317-1321

[12] Frenot, Y., Chown, S. Whinam, J. et al., 2005. Nbiological invasions in the Antarctic; extent, impacts and implications. *Biological reviews*, 80, 45-72.

[13] Petit, J.R., J. Jouzel, D. Raynaud, N.I. Barkov, J.-M. Barnola, I. Basile, M. Bender, J. Chappellaz, M. Davis, G. Delaygue, M. Delmotte, V.M. Kotlyakov, M. Legrand, V.Y. Lipenkov, C. Lorius, L. Pepin, C. Ritz, E. Saltzman, and M. Stievenard. 1999. Climate and atmospheric history of the past 420,000 years from the Vostok ice core, Antarctica. *Nature*, **399**(6735), 429-436..

3.2 Mass Balance of the Ice Sheet

By using satellite measurements of Earth's gravity field, researchers from the University of Colorado determined mass variations of the Antarctic ice sheet during 2002-2005, finding that the ice sheet mass decreased significantly, at a rate of 138 ± 73 billion tons per year. Most of this mass loss came from the West Antarctic Ice Sheet.[14] The resultant equivalent rise in global sea level amounts to 0.4 ± 0.2 mm/year, which is 10-30% of the rate of global sea level rise measured over the 20th century.

In the most comprehensive survey ever undertaken of the ice sheets covering both Greenland and Antarctica, NASA scientists confirm that climate warming is changing how much water remains locked in Earth's largest storehouses of ice and snow. "If the trends we're seeing continue and climate warming continues as predicted, the polar ice sheets could change dramatically," said survey lead author Jay Zwally of NASA's Goddard Space Flight Center, Greenbelt, Md. The survey shows that there was a net loss of ice from the combined polar ice sheets between 1992 and 2002 and a corresponding rise in sea level. It documented for the first time extensive thinning of the West Antarctic ice shelves. Net loss of ice from Antarctica was estimated to be about 31 billion tons per year, equivalent to 0.08 mm per year sea level rise.[15] The quantitative difference between these two results using very different techniques reflects the uncertainties still involved in making these very difficult measurements, but the key point is that both indicate a shift to net loss of Antarctic ice, and suggest that losses may be accelerating.

3.3 West Antarctic Ice Sheet, Melting Glaciers and Disintegrating Ice Shelves

British Antarctic Survey (BAS) 2005 studies of the melting of Antarctic Peninsula glaciers indicate that they are melting much faster than previously predicted. Some researchers have concluded that the melting of these glaciers is already likely contributing a non-negligible part to sea level rise.[16] In the Amundsen Sea sector of West Antarctica, accelerating glacier melt is now discharging enough excess ice to raise sea level more than 0.2 mm per year. This is the sector widely believed to be the most vulnerable portion of the WAIS, with the potential for a further rapid acceleration of ice discharge.[17]

The stability of Antarctic ice shelves in a warming climate has long been discussed, and the recent collapse of a significant part of the Larsen Ice Shelf off the northern Antarctic Peninsula has led to a refocus on the implications of ice shelf decay for the stability of Antarctica's grounded ice. Records from six marine sediment cores in the vicinity of the Larsen Ice Shelf demonstrate that the recent collapse of the Larsen B Ice Shelf is unprecedented during the Holocene - since the end of the last ice age more than 12,000 years ago. This research implies that the Larsen B Ice Shelf has been thinning throughout the Holocene, and that the recent prolonged period of warming in the Antarctic Peninsula region, in combination with the long-term thinning, has led to its collapse.[18]

Satellite radar measurements show that ice shelves in Pine Island Bay have thinned by up to 5.5 meters per year over the past decade. The thinning of the ice shelves, apparently from ocean currents on average 0.5°C warmer than freezing, is mirrored by the thinning of their tributaries - Pine Island, Thwaites and Smith glaciers. The imbalance of the glaciers in response to the thinning of the ice shelves shows that Antarctica is more sensitive to changing climates than was previously considered.[19] A growing body of observational data suggests that Pine Island Glacier is changing on decadal or shorter time scales. These changes may have far-reaching consequences for the future of the West Antarctic Ice Sheet (WAIS) and global sea levels because of

[14] Velicogna and Wahr, 2006, op. cit.
[15] Zwally et al., 2005, op.cit..
[16] Rignot, E., G. Casassa, S. Gogineni, P. Kanagaratnam, W. Krabill, H. Pritchard, A. Rivera, R. Thomas, J. Turner, and D. Vaughan. 2005. Recent ice loss from the Fleming and other glaciers, Wordie Bay, West Antarctic Peninsula. *Geophysical Research Letters*, **32**(7), L07502, doi:10.1029/2004GL021947..
[17] Thomas et al., 2004, op.cit.
[18] Domack, E., D. Duran, A. Leventer, S. Ishman, S. Doane, S. McCallum, D. Amblas, J. Ring, R. Gilbert, and M. Prentice. 2005. Stability of the Larsen B ice shelf on the Antarctic Peninsula during the Holocene epoch. *Nature*, **436**(7051), 681-685..
[19] Shepherd, A., D. Wingham, and E. Rignot. 2004. Warm ocean is eroding West Antarctic Ice Sheet. *Geophysical Research Letters*, **31**(23), L23402, doi:10.1029/2004GL021106..

the glacier's role as one of the ice sheet's primary drainage portals. The speed at which these changes are propagated upstream implies a tight coupling between the ice-sheet interior and the surrounding ocean.[20] Indeed, the rate of flow of these glaciers is sensitive even to the weak ebb and flow of Antarctic tides.

Antarctic Peninsula glaciers that fed the former Larsen B Ice Shelf also sped up, as Mercer warned almost 30 years ago,[21] by factors of two to eight following the collapse of the ice shelf in 2002. In contrast, glaciers further south did not accelerate as they are still buttressed by an ice shelf. The mass loss associated with the flow acceleration exceeds 27 cubic kilometers (0.07 mm sea level) per year and ice is thinning at rates of tens of meters per year. This abrupt evolution of the glaciers is attributed to the removal of the buttressing ice shelf. The magnitude of the glacier changes illustrates the importance of ice shelves on ice sheet mass balance and contribution to sea level change.[22]

3.4 Stability of the East Antarctic ice sheet

The East Antarctic Ice Sheet (EAIS) has long been regarded by glaciologists as being inherently stable. Some have predicted an increase in mass for some decades through increased snowfall from warmer temperatures.[23] Some recent measurements show such an increase,[24] whereas others suggest little change.[25] However geologists, with their longer time perspective, have for some time questioned its stability. They suggest that a well-documented 20-meter rise in sea level in a warm interglacial time as recently (geologically speaking) as 400,000 years ago can be explained only by a contribution of 8 m from East Antarctica along with the loss of the West Antarctic and Greenland ice sheets.[26] The EAIS has extensive lakes, as many as 150.[27] It is not known if these have been expanding or increasing but abundant water at the base of the ice sheet could encourage rapid ice movement.[28]

3.5 Water at the Ice Sheet Bed

Recent detailed high-resolution satellite imagery has charted the simultaneous rise and compensating fall of two patches of the EAIS over 200 km apart, reflecting the discharge of one lake into another,[29] and at the same time making us aware of the potentially destabilizing effect of extensive water movement under the ice. In West Antarctica, satellite radar data revealed areas on two ice streams moving upwards and downwards by as much as a half a meter in few weeks.[30] More recently, satellite laser altimetry has been used to plot the rise and fall of 14 regions on two other ice streams.[31] These vertical motions can only result by large-scale water movement at the beds of the ice streams, in at least one case discharging into the ocean. Although the volumes

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[20] Payne, A.J., A. Vieli, A.P. Shepherd, D.J. Wingham, and E. Rignot. 2004. Recent dramatic thinning of largest West Antarctic ice stream triggered by oceans. *Geophysical Research Letters*, **31**(23), L23401, doi:10.1029/2004GL021284..

[21]Mercer, J.H., 1978, West Antarctic ice sheet and C02 greenhouse effect: A threat of disaster: Nature, vol. 271, p. 321-325

[22] Rignot, E., G. Casassa, P. Gogineni, W. Krabill, A. Rivera, and R. Thomas. 2004. Accelerated ice discharge from the Antarctic Peninsula following the collapse of Larsen B ice shelf. *Geophysical Research Letters*, **31**(18), L18401, doi:10.1029/2004GL020697..

[23] Huybrechts P., 1993. Glaciological modelling of the Late Cenozoic East Antarctic ice sheet: stability or dynamism? Geografiska Annaler, **75A**, 221-238.

[24] Davis, C.H., Y. Li, J.R. McConnell, M.M. Frey, and E. Hanna. 2005. Snowfall-driven growth in East Antarctic ice sheet mitigates recent sea-level rise. *Science*, **308**(5730), 1898-1901.

[25] Zwally et al., 2005 op. cit.; Velicogna and Wahr, 2006, op. cit.

[26] Hearty, P. J., P. Kindler, H. Cheng, and R. L. Edwards, A +20 m middle Pleistocene sea-level highstand (Bermuda and the Bahamas) due to partial collapse of Antarctic ice, *Geology*, 27, 375-378, 1999.

[27] Siegert, M. J., Carter, S., Tabacco, I., Popov, S. & Blankenship, D. A revised inventory of Antarctic subglacial lakes. Antarctic Science. 17, 453–460 (2005). et al., 2005.

[28] Siegert et al., op. cit.

[29] Wingham, D.J., M.J. Siegert, A. Shepherd, and A.S. Muir. 2006. Rapid discharge connects Antarctic subglacial lakes. *Nature*, **440**(7087), 1033-1036.

[30] Gray, L., I. Joughin, S. Tulaczyk, V.B. Spikes, R. Bindschadler, and K. Jezek. 2005. Evidence for subglacial water transport in the West Antarctic Ice Sheet through three-dimensional satellite radar interferometry. *Geophysical Research Letters*, **32**(3), L03501, doi:10.1029/2004GL021387.

[31] Fricker, H.A., T. Scambos, R. Bindschadler, and L. Padman. 2007. An active subglacial water system in West Antarctica mapped from space. *Science*, Published Online February 15, 2007)

of water are tiny in terms of sea level change, the observations reveal a widespread, dynamic subglacial water system, which may exert an important control on ice stream flow and hence on the mass balance of the entire ice sheet. Further work is needed to understand better the implications of water flows beneath the EAIS for projections of its behavior in a warming world.

3.6 Impacts on Antarctic Krill and Other Marine Species

An inspection of Antarctic krill data collected between 1926 and 2003 in the Scotia Sea and northern Antarctic Peninsula shows an 80% decrease in krill abundance in the last 30 years. The decline was linked to loss of winter sea ice, beneath which krill over-winters. In this geographical region, such a massive reduction in krill stocks, in conjunction with over-fished fish stocks, has seriously adverse implications for middle- and upper-trophic level portions of the foodweb.[32] On the other hand, sea ice persistence and extent in East Antarctica and the Ross Sea region argues for the opposite effect. Thus, at present the implications of losing sea ice are serious but the scenario as applied to the entire Southern Ocean is not yet clear. There are no krill time series for East Antarctica.

A recent study published by scientists at the British Antarctic Survey and the University of Hull in the UK estimates that the population of krill in the Southern Ocean sequesters some 23 million tonnes of carbon each year.[33] This figure represents approximately 8% of the estimate of the total amount of carbon sequestered by all pelagic species in the so-called permanently stratified region of the world's oceans between 50 degrees north latitude and 50 degrees south latitude through 'active flux' - the deposition of carbon into the deep-ocean. The relative importance of krill as a carbon sink should be incorporated into the management regime for the exploitation of krill in the Southern Ocean.

Ocean acidification caused by increased carbon dioxide levels is raising concerns over the potential for large-scale changes to the Antarctic ecosystem.[34] The IPCC's latest assessment projects a decrease in "average global surface ocean pH of between 0.14 and 0.35 units over the 21st century, adding to the present decrease of 0.1 units since pre-industrial times."[35] A decrease in pH of 0.5 in the surface oceans corresponds to a three-fold increase in the concentration of hydrogen ions. Such a decrease in pH will have negative consequences, primarily for oceanic calcifying organanisms. Calcifying organisms in the Southern Ocean are likely to be among the first to be affected from ocean acidification.[36] Most at risk are the aragonite-producing pelagic molluscs (pteropods), which are the dominant calcifiers in the Southern Ocean.

4. Conclusions

Antarctic Treaty member states have articulated many times their special responsibility to protect the Antarctic. Now they need to exercise leadership commensurate with that responsibility to move the planet as rapidly as possible away from a carbon-based energy system. The unique information resulting from each Treaty member's own Antarctic scientific programs provides the basis for taking that urgent action. In this context, it is fitting that a major focus of the International Polar Year is climate change research, and ASOC looks forward to those results.

ASOC urges all Antarctic Treaty member states to take emission reduction actions based on the realities revealed by Antarctic research, as well as on the profound litany contained in the latest IPCC report.

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[32] Atkinson, A., Siegel, V., Pakhomov, E., Rothery, P., 2004. Long-term decline in krill stock and increase in salps within the Southern Ocean. *Nature* 432: 100-103); Myers, R.A. Worm, B. 2003. Rapid worldwide depletion of predatory fish communities. *Nature* 423, 280-283; Pauly, D., Christiansen, V., Dalsgaard, J., Froeser, R., Torres Jr., F. 1998. Fishing down marine food webs. *Science* 279, 860-863; Pauly, D., Watson, R., Alder, J. 2005. Global trends in world fisheries: impacts on marine ecosystems and food security. *Philosophical Transactions of the Royal Society B* 360, 5–12.

[33] Tarling G. A. and M. L. Johnson, "Satiation gives krill that sinking feeling," Current Biology, 16(3), February 2006, pp. R83-84.

[34] Wright S and A. Davidson (2006) Ocean Acidification: a newly recognised threat. Australian Antarctic Magazine. Autumn 2006 p26-27.

[35] IPCC (2007) Climate Change 2007: The Physical Science Basis: Summary for Policymakers - Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Feb 2007, 18p.

[36] Raven J *et al.* (2005). Ocean acidification due to increasing atmospheric carbon dioxide. The Royal Society. London 57 pp. (Download at: <http://www.royalsoc.ac.uk/document. asp?id=3249>).

Governments urgently need to take tangible steps both domestically and through international treaties and other arrangements to reduce emissions in order to address the threats posed by climate change.

ASOC requests the Consultative Parties to take the following steps at this ATCM:

- Issue a Resolution or other appropriate instrument acknowledging that the largest single threat facing the Antarctic is climate change, and pledging to take steps both in the Antarctic and at the global level to avoid dangerous climate change.

- In an appropriate way, urge CCAMLR Parties to ensure that harvesting of krill does not adversely impact its capacity to serve as a carbon sink.

- Establish a mandatory obligation to record the greenhouse gas emissions from stations, field camps, aircraft and vessels of all types – including tourism, fishing, whaling, scientific research, logistical supply, and fuel delivery vessels and aircraft.

- Initiate additional steps to reduce the greenhouse gas emissions from these sources through renewable energy initiatives at each station and field camp, and through other approaches for other sources. The IPY provides a good platform for inducing all actors in the region to employ conservation, energy efficiency and renewable energy to the maximum extent possible.

- Establish a formal program to off-set greenhouse gas emissions from all station, vessel and aircraft, given that those are not covered by the Kyoto Protocol, and put it into operation by 2008.

- Ensure the CEP's new 5-year strategic plan adequately integrates climate change aspects within each of the prioritized work areas, and commit to a high-level review of the climate change-related results from the IPY in 2009.