Chapter 7

The New SCAR (2004–08)

Introduction

The history of SCAR changed dramatically with the re-organization, becoming both more complex and more wide-ranging. The linkages between the major science programmes, the Standing Science Groups and their many committees, as well as the explosion in links with outside organizations means that the structure of this chapter cannot easily follow the format used in the earlier chapters. As will become clear science initiatives and the whole pace of change have moved what was a rather sedate organization into a wholly new level of activity.

With its recent reorganization, SCAR was well-positioned to make use of this exciting opportunity and decided to concentrate on three key areas: how Antarctic processes contribute to the working of the Earth System, and vice versa; how the south polar environment is influenced by human activities originating both within and outside the region; and what needed to be done to safeguard the environment.

It was not only SCAR's reviewers that had called for change. In reviewing the performance of all of its environmental bodies, ICSU's 2003 "Report on Environment and its Relation to Sustainable Development" concluded that "The importance of SCAR has increased over the years with greater understanding of the pivotal role of the Antarctic in the Earth System and its numerous connections with other physical and biological elements including space weather and Sun-Earth interactions. Antarctic science therefore has global relevance".

The restructuring of SCAR had provided three Standing Scientific Groups (SSGs) - for the Life Sciences (SSG-LS), the Geosciences (SSG-GS) and the Physical Sciences (SSG-PS) with their associated Action Groups for issues demanding a rapid response, and Expert Groups for issues of a more permanent nature, together with a small number of Scientific Research Programmes (SRPs) addressing questions of global scientific interest, some with considerable socio-economic significance.

The basic framework had thus been set, but a Strategic Plan was needed to set out the vision, mission and objectives of the organization. These would include employment of an Executive Director to steer the organization, and a biennial Open Science Conference to reach out to the wider community. Dr Colin P Summerhayes appointed as Executive Director, began to draft the SCAR Strategic Plan 2004-2010 (see box) agreed by the Delegates at XXVIII SCAR (Bremerhaven, October 2004).

SCAR decided that it should concentrate on innovative high quality international science programmes addressing issues of global importance, providing a forum for excellence in Antarctic science as well as establishing new regional and international scientific networks and encouraging multi-disciplinary co-operation in relevant fields. It was also clear that SCAR would need assistance from elsewhere in ICSU

SCAR Strategic Plan 2004–2010

Vision:

"To establish through scientific research and international cooperation a broad understanding of the nature of Antarctica, the role of Antarctica in the Earth System, and the effects of global change on Antarctica."

Mission:

"To be the leading independent organization for facilitating and coordinating Antarctic research, and for identifying issues emerging from greater scientific understanding of the region that should be brought to the attention of policy makers".

Main Objectives:

- to initiate, develop, and co-ordinate high quality international scientific research in the Antarctic region, and on the role of the Antarctic region in the Earth system;
- to provide objective and independent scientific advice to the Antarctic Treaty Consultative Meetings and other organizations on issues of science and conservation affecting the management of Antarctica and the Southern Ocean.
- to facilitate free and unrestricted access to Antarctic scientific data and information;
- to develop scientific capacity in all SCAR Members, especially with respect to younger scientists, and to promote the incorporation of Antarctic science in education at all levels;
- to communicate scientific information about the Antarctic region to the public.
- to improve the effectiveness, efficiency and flexibility of the structure, working mechanisms and practices of SCAR.
- to increase funding to match requirements, and to maintain a healthy funding stream.

so that better links needed to be made with groups like SCOR. Special attention was to be paid to data access and management, especially through the existing World Data Centres and the JCADM initiatives. To ensure this happened a SCAR data and information strategy also needed to be developed.

SCAR also expanded its geographical remit to include the Southern Ocean from the Antarctic coast north to the Subantarctic Front, to recognize the important role of the Antarctic Circumpolar Current in controlling Antarctic climate.

Key global features of Antarctic science

A pressing requirement was a better understanding of Antarctica's role in the Earth's climate system in order to make accurate forecasts of climate change. This required comprehensive observation and analysis of the roles of the Antarctic atmosphere, ocean and cryosphere (comprising snow, ice and permafrost) both now and in the past. Antarctica's crucial role was highlighted by the observation that the major changes in sea-level that have characterized the past few millions of years have been controlled largely by changes in the Antarctic ice sheet.

The Southern Ocean plays a key role in the global climate system, being the medium through which critical exchanges of heat, salt, carbon, oxygen and nutrients take place between Antarctica and the rest of the world. Knowing how the Southern Ocean marine ecosystem evolved will help us to understand evolutionary pathways including the possible connection between the Antarctic deep-sea benthos and the benthic species in the other deep oceans.

Deep beneath the ice sheet more than 160 extensive subglacial lakes now appear to be part of an immense interconnected, hydrological system whose implications for ice movement may be critical.

The ice sheet also hides much of the geological history of Antarctica such as the Gamburtsev Subglacial Mountains beneath the East Antarctic Ice Sheet. How did these features come to be there, and how did they influence the growth of the ice sheet?

Studies of the Antarctic atmosphere are essential for the forecasting of weather conditions, and to understand the chemical processes taking place high in the stratosphere above Antarctica that result in the ozone hole.

Antarctica is one of the best places to study "geospace" the region where the Earth's atmosphere interacts with the solar wind, a supersonic stream of charged particles emitted from the sun's corona. The interaction of the solar wind with the Earth's magnetic field creates the aurora australis as well as a wide range of other effects including geomagnetic storms, disruptions in short-wave radio communications, and power surges in long electricity transmission lines.

Antarctica is also one of the best places in the world from which to study the cosmos, because the skies above the Antarctic plateau are the coldest, driest and most stable on Earth, allowing observations across the electromagnetic spectrum from the near ultra-violet to the millimetre wavebands.

Everything SCAR does, and how SCAR is perceived as an organization, is rooted in its science. Even SCAR's advice to the Antarctic Treaty System can only be effective if SCAR is scientifically strong. Its five main research programmes are peer-reviewed every four years by the wider community, whilst internal assessments are carried out annually by the Executive Committee (EXCOM) and biennially by the SCAR Delegates. All of SCAR's science programmes are "bottom-up", being invented within the Scientific Standing Groups. And all of SCAR's scientific planning, reporting and review is carried out by volunteers. A regular Cross-Linkages workshop involving the Chief Officers of the Scientific Standing Groups and the leaders of the Scientific Research programmes provides an incubator for the generation of new programme proposals.

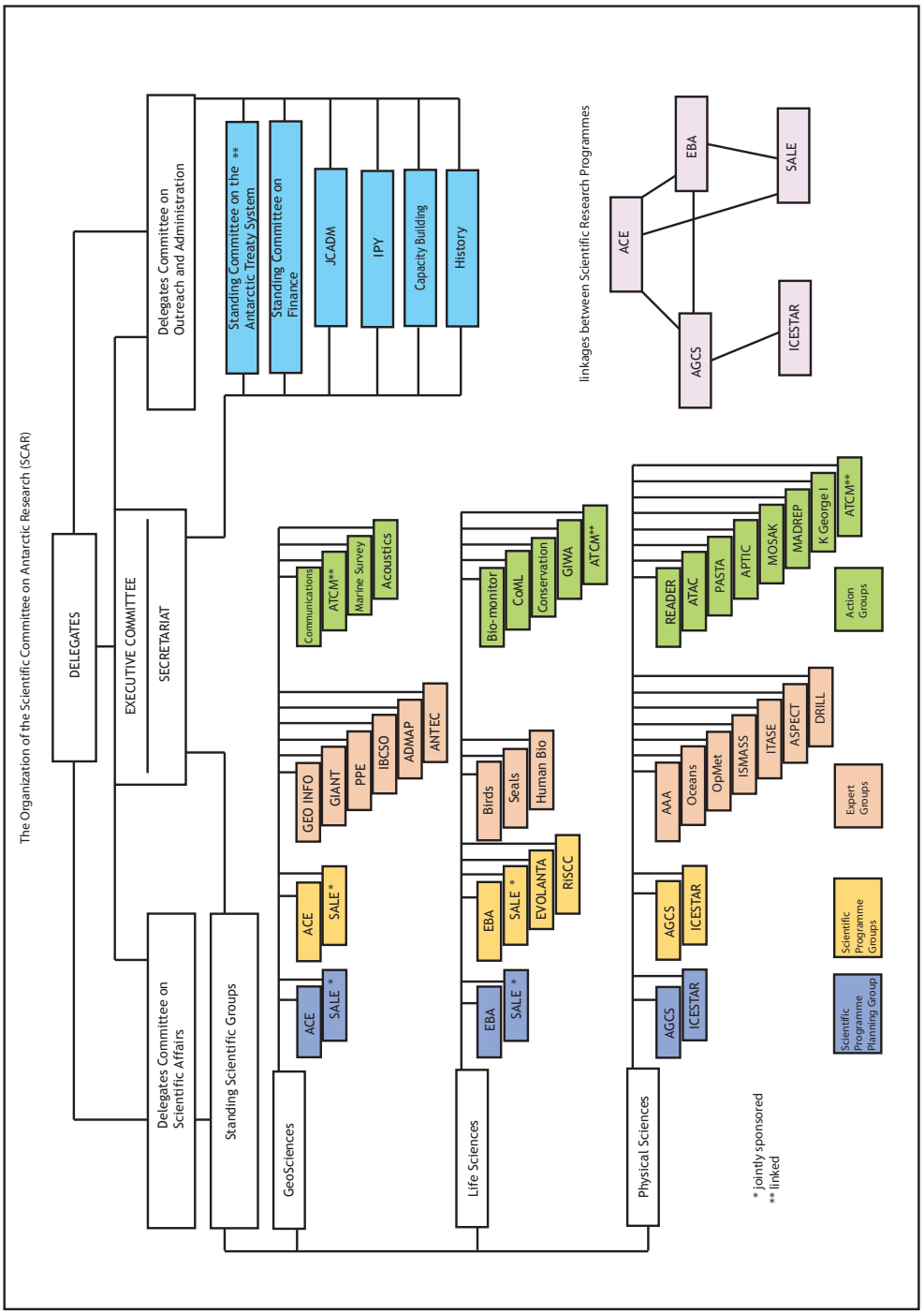
SCAR's science delivery

The first five approved programmes were:

a. Antarctica and the Global Climate System (AGCS), a study of the modern ocean-atmosphere-ice system;
b. Antarctic Climate Evolution (ACE), a study of climate change since glaciation began about 34 million years ago;
c. Evolution and Biodiversity in the Antarctic (EBA), a study of the response of life to change;
d. Subglacial Antarctic Lake Exploration (SALE), a study of the chemistry and biology of lakes long buried beneath the ice sheet;
e. Interhemispheric Conjugacy Effects in Solar-Terrestrial and Aeronomy Research (ICESTAR), a study of the response of the Earth's outer atmosphere to the changing impact of the solar wind at both poles.

The Delegates' Meeting in 2004 decided that the Scientific Standing Groups should receive around US $17,000 per year for their various Action and Expert Groups, and hoped to provide US $25,000 per year for each of the large Scientific Research Programmes (SRPs). Unfortunately the budget has never quite measured up to expectations.

The five SRPs are described as parts of the three SSGs, through whom they report to the EXCOM and Delegates. Their value and progress are not just about producing leading edge pan-Antarctic science but also in arranging meetings, planning field activities, reviewing progress in


The Organization of the Scientific Committee on Antarctic Research (SCAR)
DELEGATES
EXECUTIVE COMMITTEE
SECRETARIAT
Delegates Committee on Outreach and Administration
Delegates Committee on Scientific Affairs
Standing Scientific Groups
Standing Committee on the ** Antarctic Treaty System
Standing Committee on Finance
JCADM
IPY
Capacity Building
History
GeoSciences
ACE
SALE *
GEO INFO
GIANT
PPE
IBCSO
ADMAP
ANTEC
Communications
ATCM**
Marine Survey
Acoustics
Life Sciences
EBA
SALE *
EVOLANTA
RiSCC
Birds
Seals
Human Bio
Bio-monitor
CoML
Conservation
GIWA
ATCM**
Physical Sciences
AGCS
ICESTAR
AAA
Oceans
OpMet
ISMASS
ITASE
ASPECT
DRILL
READER
ATAC
PASTA
APTIC
MOSAK
MADREP
K George I
ATCM**
Scientific Programme Planning Group
Scientific Programme Groups
Expert Groups
Action Groups
* jointly sponsored
** linked
linkages between Scientific Research Programmes
ACE
EBA
SALE
AGCS
ICESTAR

science and agreeing on what, where and when to publish.

A key element of this new framework is partnerships, of which one of the most important is the link with COMNAP. SCAR co-ordinates its activities with COMNAP through:

a. meetings of the SCAR and COMNAP Executives;
b. joint meetings of the full memberships of both organizations in even numbered years; and
c. liaison in the margins of the ATCM meetings.

SCAR now has formal Letters of Agreement or Memoranda of Understanding for scientific collaboration with the WCRP, with the Global Ecosystems Dynamics (GLOBEC) programme of the IGBP, with the International Arctic Science Committee, the International Permafrost Association, and the International Association of Cryospheric Sciences.

Standing Scientific Group on Life Sciences (SSG-LS)

The 9th Biology Symposium took place in Curitiba, Brazil, in July 2005, with the theme of "Evolution and Biodiversity in Antarctica" and was the first one in Latin America. Despite enormous funding problems in the course of which the organizer, Edith Fanta, was forced borrow money against her own assets, due to the tardiness of government departments, it was a memorable occasion. There were 246 oral and poster presentations from 29 countries, with 70 from Brazil, and a selection of the papers was published in a special issue of *Antarctic Science*. The 10th Symposium in Hokkaido University, Sapporo, Japan, 26–31 July 2009 was the first in Asia. Led by Mitsuo Fukuchi of the National Institute for Polar Research it focused on the early outcomes of the IPY with over 110 oral presentations and 130 posters, 40% of which were by early career scientists. Many of the presentations will be published in a special issue of *Polar Science*, rather than as a book. New to the symposium was a special outreach event and awards for the best ten presentations by young researchers.

Left to right: Clive Howard-Williams, Jerónimo López-Martínez, John Turner, Steven Chown and Alessandro Capra at a dinner during the meeting of the SCAR Executive Committee and Chief Officers in Brest, France, July 2005.

Meeting of the SCAR Executive Committee and Chief Officers in Washington DC, USA, July 2007. Clockwise from the left: Alessandro Capra, Sergio Marenssi, Chris Rapley, Colin Summerhayes, Mike Sparrow, Toni Meloni and Taco de Bruin.

Following extensive consultation within SCAR and COMNAP, the SSG-LS produced a unified code of conduct for fieldwork anywhere in the Antarctic, including protected areas, and agreed a revised version of the Code of Conduct for the use of animals in Antarctic experiments. A new Cross-SSG Action Group was formed on the Code of Conduct for the Exploration and Research of Subglacial Aquatic Environments (AG-CCER-SAE), led by Warwick Vincent (Canada).

During 2005, SCAR launched the Census of Antarctic Marine Life (CAML) Expert Group led by Michael Stoddart (Australia), a five-year international project

Participants at the final symposium of the EASIZ programme held in Korčula, Croatia, in 2004. Photograph: Andrew Clarke.

funded by the Alfred P Sloan Foundation as part of the Foundation's global Census of Marine Life, together with additional funds from Memorial University. CAML aimed to investigate the distribution and abundance of Antarctica's marine biodiversity, to see how biodiversity is affected by environmental change, and how change will alter the nature of the ecosystem services provided to the planet by the Southern Ocean. In addition to traditional taxonomy, the use of powerful new tools for genetic sequencing would determine the extent to which the Antarctic marine fauna and flora were responding to change. Sloan funding provided for a CAML Office, hosted by the Australian Antarctic Division.

EASIZ members during the 2004 meeting in Croatia. From the left: Walker Smith, Dominic Hodgson and Andrew Clarke. Photograph: Dominic Hodgson.

In 2006 the first CAML cruise began in December, aboard *Polarstern*, around the Antarctic Peninsula. The World Conference on Barcoding in Taipei in September 2007 provided directions and contacts for CAML's special DNA bar coding project, and CAML began to prepare an Encyclopedia of Antarctic Marine Life as a contribution to the global Census of Marine Life (CoML).

Evolution and Biodiversity in the Antarctic (EBA) was focused on the evolutionary history of Antarctic organisms; their adaptation to the Antarctic environment; the patterns of gene flow and consequences for population dynamics; the diversity of organisms, ecosystems and habitats in the Antarctic; and the impact of past, current and predicted future environments. Among other things EBA assisted in the production of scientific advice to the Antarctic Treaty Parties and CCAMLR.

As EBA started during 2004 and 2005, its two predecessor programmes were wound down. One of these was Evolutionary Biology of Antarctic Organisms

(EVOLANTA), a primarily marine programme that would continue in modified form in EBA, and which published the proceedings of one of its workshops as a special issue of *Antarctic Science*. The other was Regional Sensitivity to Climate Change in Antarctic Terrestrial and Limnetic Ecosystems (RiSCC), a terrestrial programme which would also be incorporated into EBA, and which completed three successful field campaigns during this period: the three island study of Marion, Kerguelen, and Heard islands (France – Australia – South Africa – UK); the Antarctic Peninsula transect (Netherlands – United Kingdom), and the Latitudinal Gradient Project in Victoria Land (New Zealand – Italy – United States). From the start, EBA was something of an experiment in that it brought together quite separate marine and terrestrial research elements. The merger created tensions that were eventually resolved at a stressful workshop near Eindhoven airport in the Netherlands, enabling the construction of the EBA science plan.

To mark the end of its efforts, in 2006 the RiSCC team produced a synthesis volume – *Trends in Antarctic Terrestrial and Limnetic Ecosystems, Antarctica as a Global Indicator* – establishing how Antarctic land, lake and pond life respond to climate change, and identifying the processes determining community response to stress. The EVOLANTA team also produced a number of publications to complement their 2004 special issue of *Antarctic Science*. The Latitudinal Gradient Programme (LGP), published several papers in a special issue of *Antarctic Science* in December 2006, whilst a synthesis volume from the final meeting of the Ecology of the Antarctic Sea Ice Zone (EASIZ) programme was published in in *Deep Sea Research II* 2006, providing new understandings about the diversity, ecology and population dynamics of the organisms beneath the Antarctic sea ice, and their sensitivity to change.

The EBA Implementation Plan had five different work packages:

a. Evolutionary history of Antarctic organisms;
b. Evolutionary adaptation to the Antarctic environment:
c. Patterns of gene flow and consequences for population dynamics: isolation as a driving force:

Participants at the EVOLANTA Workshop held in March 2000 at Down House, Kent, United Kingdom, the former residence of Charles Darwin. Left to right: Donald Siniff, Sang-Hoon Lee, Joe Eastman, Jean-Claude Hureau, Julian Gutt, Pat Gaffney, Paul Rodhouse, Guido di Prisco, Pat Selkirk, Edith Fanta, Bruno Battaglia and Nick Russell. Photograph: Paul Rodhouse

d. Patterns and diversity of organisms, ecosystems and habitats in the Antarctic, and controlling processes;

e. Impact of past, current and predicted future environmental change on biodiversity and ecosystem function.

Despite its difficult start, EBA has been a success, although the marine and terrestrial research groups were never able to integrate as well as had been hoped. Particular successes are evident in the Census of Antarctic Marine Life (CAML) and in the development of a major effort on microbial life. Significant progress has also been made on the terrestrial side in biodiversity and palaeobiogeography.

EBA was both a SCAR and an IPY programme. Several other projects that contributed to EBA were also IPY endorsed projects such as the Census of Antarctic Marine Life (CAML), Marine Biodiversity Information Network (MarBIN), Aliens, TARANTELLA, MERGE, the Latitudinal Gradient Project, and Integrating Climate and Ecosystem Dynamics in the Southern Ocean (ICED). Of these, CAML, MarBIN and ICED were either SCAR activities or sponsored by SCAR, and part of the list of some 40 national and international programmes contributing to EBA.

The SCAR Marine Biodiversity Information Network set up the first authoritative Register of Antarctic Marine Species (RAMS), which feeds larger taxonomic systems such as the World Register of Marine Species, the Catalogue of Life, or the Encyclopaedia of Life. RAMS includes information on 13,000+ taxa and is updated and checked by a board of specialists. MarBIN also gives access to occurrence and abundance data from 115 interoperable databases, reaching over 913,000+ records, which are also published through the Ocean Biodiversity Information System (OBIS) and the Global Biodiversity Information System (GBIF). Developments included a new data portal to give access to new features, including genetic data, expeditions and experts databases, interactive identification keys, field guides and a new intuitive interface including a powerful search engine. MarBIN was funded wholly by the Belgian Science Policy Office until September 2009, and has subsequently successfully gained other additional sources of support to sustain its future, in particular from the Total Foundation.

Progress under Work Package 2 included work on genes and proteins in polar fish and bacteria to understand their evolutionary adaptation to Antarctic conditions.

Through SCAR-MarBIN, the ANTOBIS geodatabase (forming the Antarctic node of the Ocean Biogeographic Information System, OBIS) had reached 1,054,676 records from 145 distributed databases.

Together, SCAR-MarBIN and CAML meet the need to establish the current state of Antarctic marine communities and their diversity, so that we can understand the impact of future climate change, and the changes wrought by human activities such as overfishing and pollution.

EBA's success is reflected in part in publications emerging from its scientific community that totalled at least 159 peer-reviewed papers in 2007, more than 150 EBA-related publications in 2008, and a similar number in 2009.

By 2008 CAML was seen as one of the major achievements of the IPY. It had pioneered new understandings of the evolution and diversity of life, and provided comprehensive baseline information on Antarctic marine biodiversity. Scientific results were being made available via SCAR-MarBIN. In partnership with Canada's Guelph University, CAML was 'barcoding' (analysing DNA sequences) for some 2,000 Antarctic species, with SCAR-MarBIN creating related data storage, analysis and visualization tools.

By 2009 CAML had established a benchmark of over 16,000 taxa of biota in the Southern Ocean, and CAML researchers had discovered new pathways of evolution, dispersal and colonization by Antarctic organisms. A comparison of the

The 3rd Cross-linkages workshop in Modena, Italy (2009) organized by Roberto Cervellati, with Colin Summerhayes, Alessandro Capra, Maurizio Candidi, Kathy Conlan, John Storey, Carlota Escutia Dotti, Guido di Prisco, Kim Finney, Rachold Volker, John Turner, Dominic Hodgson, Carlo Barbante, Mahlon Kennicutt, Heinz Miller, Annika Seppälä, Toni Meloni. Photograph: Dominic Hodgson

A biological sciences programme planning workshop in Castiglioncello, Italy, May 2010, was organized by Piero Luporini. Present were Dominic Hodgson, Antonio Quesada, Julian Gutt, Angelika Brandt, Marc Lebouvier, Wim Vyverman, Brett Sinclair, Dana Bergstrom, Martin Riddle, Clive Howard-Williams, Lucia Campos, Diana Wall, Kathey Conlan, Ad Huiskes, Louise Newman, Shulamit Gordon, Cincia Verde, Guido di Prisco, Peter Convey, Andy Clarke, Katrin Linse, Renuka Badhe. Photograph: Dominic Hodgson.

species in Antarctic and Arctic waters was possible for the first time, inspired by the IPY. Training the next generation of researchers has been a priority, implemented by funding young scientists to join voyages and attend conferences.

In the last five years, CAML had contributed data to SCAR-MarBIN; co-ordinated intensive Continuous Plankton Recorder sampling, showing changes in zooplankton communities; discovered hundreds of new species; published barcodes for

Wet excursion to Cradle Mountain during the 3rd RiSCC workshop in Hobart. Photograph: Ad Huiskes

In the Subantarctic House at Hobart Botanical Gardens during the 3rd RiSCC workshop. Photograph: Ad Huiskes.

Excursion to Stelvio Pass during 4th RiSCC workshop at Varese in Italy. Photograph: Ad Huiskes

2,500 species (from over 11,000 DNA sequences); posted web-based media from each voyage and three major international press events; and produced a video on YouTube with another in progress. Lasting legacies from CAML are the 30-year benthic dataset from Admiralty Bay; a biological contribution to the Southern Ocean Observing System, including biologger data from marine mammals; writing taxonomic monographs, Antarctic field guides and pages for the *Encyclopaedia of Life*; publication of over 1,000 scientific papers; and providing evidence for CCAMLR's bioregionalization and declaration of two Vulnerable Marine Ecosystems.

Sir Alister Hardy had recognized as long ago as 1931 the value to monitoring change in the marine planktonic community in the North Sea. His continuous plankton recorder was designed to be towed behind "ships of opportunity" and began initially to characterize North Atlantic plankton on a monthly basis. Its application spread slowly and, recognizing how such biological measurements could contribute to understanding oceanographic changes in the Southern Ocean, XXIX SCAR in Hobart established a new Action Group on Continuous Plankton Recorder Research (CPRAG) led by Graham Hosie (Australia). The Group developed the SCAR Southern Ocean CPR Survey based at the Australian Antarctic Division, mapping the biodiversity and distribution of plankton, including euphausiid (krill) life stages, and then using the sensitivity of plankton to environmental change as early warning indicators of the health of Southern Ocean. CCAMLR uses the data in its bioregionalization research, a first step towards the possible development of Marine Protected Areas.

In 2006, the Expert Group on Birds, led by Eric Woehler (Australia) continued to provide advice on bird populations and to define Important Bird Areas in the Southern Ocean region. The Expert Group on Seals, led initially by Arnoldus Blix (Norway) and subsequently by Marthan Bester (South Africa), completed the final report of the Antarctic Pack Ice Seals (APIS) project. The Group also provided a recommendation to the ATCM that the Ross Seal should continue to have the status

of a Specially Protected Species. At XXX SCAR in St Petersburg in 2008, Delegates approved the merger of the two groups to form the new Expert Group on Birds and Marine Mammals, initially chaired by Donna Patterson (USA) and subsequently by Mark Hindell (Australia). Some long-term research objectives of the Group include the compilation of all existing bird and mammal tracking data and the development of a new Southern Ocean predator community study.

The Biological Monitoring Action Group hosted a workshop in Texas, USA in March 2005, to develop a biological protocol updating and combining existing biological, physical and chemical monitoring protocols for the Antarctic, publishing "*Practical Biological Indicators of Human Impacts in Antarctica*" before being disbanded. A scoping workshop on Antarctic conservation was held at Stellenbosch in South Africa in May 2005, with the purpose of updating conservation strategies for the Antarctic.

SCAR became a co-sponsor of the Southern Ocean (SO) programme of Global Ocean Ecosystems Dynamics (GLOBEC) which focused on the year-round lifecycle of Antarctic zooplankton, particularly krill and the predators of krill, such as marine mammals and seabirds. SO-GLOBEC was concerned with the development and testing of ecosystem models to be used as the basis for forecasting trends and patterns in the krill.

With the end of SO-GLOBEC, efforts to understand the operation of the Southern Ocean ecosystem continued through a new Southern Ocean component of IGBP, Integrated Marine Biogeochemistry and Ecosystem Research (IMBER) which SCAR co-sponsors. The Integrating Climate and Ecosystem Dynamics in the Southern Ocean (ICED) programme, led by Eugene Murphy (UK) aims to predict how the diverse Southern Ocean ecosystems will respond to climate change, and the impacts of marine ecosystem change on the Earth System. ICED has brought together oceanographers, biogeochemists, climatologists, and ecosystem and fisheries scientists to address three key questions:

1. How do climate processes affect the dynamics of circumpolar ecosystems?
2. How does ecosystem structure affect circumpolar ocean biogeochemical cycles?
3. How should ecosystem structure and dynamics be included in sustainable approaches to fisheries management?

Standing Scientific Group on Physical Sciences (SSG-PS)

The SSG-PS, led by Chief Officer John Turner (UK) to 2006, followed by Maurizio Candidi (Italy) in 2006–10 had two major Scientific Research Programmes and a number of smaller programmes.

Antarctica in the Global Climate System (AGCS) was set up to investigate the linkages between the climate of the Antarctic and the rest of the Earth system over the past 10,000 years, with particular reference to the behaviour of and interactions between the atmospheric, oceanic and cryospheric elements of the climate system. It was expected to provide data to improve confidence in the outputs of numerical forecasts of climate change for the next 100 years. Its activities were divided between four major, closely linked themes dealing with:

1. Decadal time scale variability in the Antarctic climate system (leader Dave Bromwich, USA);
2. Global and regional climate signals in ice cores (leader Paul Mayewski, USA);
3. Natural and anthropogenic forcing on the Antarctic climate system (leader John Turner, UK); and
4. The export of Antarctic climate signals (leader Mike Meredith, UK, and subsequently Alberto Naveira Garbato, UK).

In addition it had two SCAR Expert Groups – International Trans-Antarctic Scientific Expeditions (ITASE), led by Paul Mayewski (USA), and Antarctic Sea-Ice Processes and Climate (ASPeCt), led by Anthony Worby (Australia).

AGCS scientists reported that balloon-launched radiosonde data for the Antarctic extending back into the 1950s had revealed a major warming of the Antarctic winter troposphere that was larger than any previously identified regional tropospheric warming on Earth. Peak warming was close to 5 km above sea level, where temperatures had increased at a rate of 0.5 – 0.7°C per decade over the last 30 years. They also investigated the variability of the linkages between the El Niño-Southern Oscillation (ENSO) and the climate of the high latitude South Pacific, and found that there was a sharp annual contrast between the 1980s and the 1990s, with the link in the 1990s being significantly amplified. Recent trends in Antarctic snow accumulation suggested that changes did not mitigate current sea level rise.

The West Antarctic Peninsula (WAP) was known to be undergoing one of the most rapid atmospheric warmings of any region in the world, with mean annual temperatures having risen by nearly 3°C in the past 50 years and by a mean of 5°C in winter, while air temperatures in East Antarctica had remained steady or fallen. In the Bellingshausen Sea significant warming had occurred in the mean summertime surface and near-surface ocean, of greater than 1°C – greatly exceeding general rates of warming in the world ocean, and one of the most rapid regional ocean warmings noted to date. The data also suggest that the initial cause of the climate change here may be atmospheric in origin, rather than oceanic.

Since the mid-1960s rapid regional summer warming has occurred on the east coast of the northern Antarctic Peninsula, with near-surface temperatures increasing by more than 2°C. This warming contributed significantly to the collapse of the northern sections of the Larsen Ice Shelf in 2002. The explanation is that over the last few decades the Southern Annular Mode (SAM) shifted into a positive phase, with surface pressures dropping over the Antarctic and rising in mid-latitudes, causing the westerly winds to increase, especially in summer. These strong westerly winds were able to take warm maritime air across the mountain barrier of the Antarctic Peninsula to melt the ice shelves. Model experiments showed that the observed shift in the SAM to its positive phases in recent decades was larger than anything occurring in long simulations of the present climate. For that reason the shift was thought to be predominantly a response to anthropogenic forcing, and provided the first evidence that increasing levels of greenhouse gases contributed, at least in part, to the observed rapid warming on the Antarctic Peninsula.

The ASPeCt Expert Group continued to develop its database of sea ice parameters from *in situ* ship observations. The ITASE Expert Group collected more than 240 firn cores (for a total of 7,000 m) and about 20,000 km of snow radar, and developed multi-centennial scale proxies for sea ice, winds and regional temperature.

In 2006 a study using output from the latest generation of climate models found that they reproduce the observed mid-depth Southern Ocean warming of 0.2°C that has occurred since the 1950s if they include time-varying changes in anthropogenic greenhouse gases, sulphate aerosols and volcanic aerosols in the Earth's atmosphere. The agreement between observations and climate models suggested significant human influence on Southern Ocean temperatures. Climate models that did not include volcanic aerosols produced mid-depth Southern Ocean warming that was nearly double that produced by climate models that did include volcanic aerosols. This implies that the full impact of human-induced warming of the Southern Ocean has yet to be realized.

In April 2006 a workshop was held in Cambridge, UK to consider the strength and weaknesses of the high latitude elements of the historical atmospheric data sets, the re-analysis of which is proving a very powerful tool for the investigation of recent climate change. Means were also considered for the collection and digitization of historical Antarctic meteorological observations for the next round of re-analyses that are to be produced. The first issue of the AGCS Newsletter *Notus* was distributed in October 2006.

The Australian Antarctic Data Centre had made good progress in establishing a sea-ice data portal for *in situ* sea-ice data, as recommended by the International Workshop on Antarctic Sea-Ice Thickness, co-sponsored by SCAR and CliC in Hobart in July 2006. SCAR funded a student to source and enter data from almost 150 files from various national programmes.

AGCS led the organization of the Second Workshop on Recent High Latitude Climate Change (Seattle, USA; 22–24 October 2007), a joint effort with IASC and the WCRP/SCAR/IASC Climate and the Cryosphere (CliC) project that considered atmospheric, oceanic and cryospheric changes that had taken place during the last 50 years in the Arctic and Antarctic.

In 2008, AGCS scientists devoted considerable efforts to completing the draft review on Antarctic Climate Change and the Environment (ACCE), synthesizing knowledge on past present and possible future changes in Antarctica and the Southern Ocean and their impact on the biota.

Analysis of air temperatures over Antarctica from 1960–2007, using data from SCAR's READER database, showed that near-surface warming on the Antarctic Peninsula had spread into West Antarctica, reaching as far east as the Pine Island Bay–Thwaites Glacier region. Weak near-surface warming was found over East Antarctica .

Work on the ACCE review provided the basis for determining the mass balance of the Antarctic Ice Sheet. West Antarctica appears to be losing mass whilst East Antarctica remains largely stable, ACCE also helped to create an unprecedented spatio-temporal array of information about the ice sheet as the basis for exploring the variability and recent evolution of Antarctic climate, and used new geological data and numerical modelling to explain the history of the ice sheets and climate since extensive glaciation began 34 million years ago.

AGCS routinely recovered and archived Antarctic data, and had updated the Meteorology, Ice and Southern Ocean READER databases. The Australian Antarctic Data Centre contributed by archiving data on Antarctic sea ice and snow thicknesses collected over the past 30 years from ship expeditions; 80% of the known data were now archived.

In 2009, after undergoing extensive review, together with colleagues from ACE and EBA, AGCS completed the revisions of the cross-SCAR review on *Antarctic Climate Change and the Environment*, which was published in October 2009. The report was made available via the SCAR web-site, but hard copies were provided ahead of time to the national delegations attending the UN Framework Convention on Climate Change conference held in Copenhagen in December 2009.

Interhemispheric Conjugacy Effects in Solar–Terrestrial and Aeronomy Research (ICESTAR) planned to create an integrated, quantitative description of the upper atmosphere over Antarctica, and of its coupling to the global atmosphere and the geospace environment. It was designed as a bipolar programme that would co-ordinate its bipolar activities with the Polar Research Working Group of the International Association of Geomagnetism and Aeronomy (IAGA). A scientific benefit would be that global-scale co-ordination of observing networks would allow study of conjugate and multi-scale geospace phenomena in fundamentally new ways. A practical benefit would be improved prediction of space weather phenomena that adversely affect spacecraft opera-

tions, humans in space, satellite-based positioning systems and electrical and communication systems on Earth and in space.

ICESTAR planned to operate with four Thematic Action Groups:

1. quantification of the coupling between the polar ionosphere and neutral atmosphere from the bottom-to-top and the global electric circuit;
2. quantification of the inner magnetospheric dynamics using remote sensing techniques;
3. quantification of the state of the upper atmosphere, ionosphere, and magnetosphere over the Antarctic continent and how it differs from the Northern Hemisphere during a wide range of geophysical conditions; and
4. creation and management of a data portal.

By 2006, ICESTAR research was able to demonstrate that:

a. conjugate studies of aurora showed that the onsets of simultaneous Arctic and Antarctic substorms are not symmetric, which has implications for predicting space weather events; and
b. satellite observations suggested that the global rate of merging between interplanetary magnetic fields and Earth's magnetosphere drives near-Earth space weather, which implies that, contrary to prevailing wisdom, space weather cannot best be predicted by the behaviour of solar wind electric fields.

By this time an ICESTAR proposal "Heliosphere Impact on Geospace" had been accepted for the IPY, to be shared with the International Heliophysical Year (IHY). Its science fell into three main themes:

1. coupling processes between the different atmospheric layers and their connection with the solar activity;
2. energy and mass exchange between the ionosphere and the magnetosphere; and
3. inter-hemispheric similarities and asymmetries in geospace phenomena.

ICESTAR made rapid progress in geospace–atmosphere coupling and by 2007 was able to show that lightning during strong thunderstorms launches electromagnetic waves that propagate both in the wave-guide between the Earth surface and ionosphere (spherics) and along geomagnetic field lines (whistlers). Combined observations from VLF-antennas, lightning detection systems, and the French DEMETER satellite looking at ionospheric disturbances showed a causal relationship between lightning and electron precipitation events.

Auroral events in both hemispheres are known to be linked (inter-hemispheric conjugacy) and recent observations with ground-based all-sky TV-cameras confirmed this conjugacy but also showed some non-conjugate auroras:

a. pulsating auroras in both hemispheres with different spatial appearance and period, and
b. pulsating auroras in one hemisphere only.

Riometers were emerging as an important tool in space science. The growing global network of riometers facilitates studies of processes involving the production, transport, and loss of high-energy magnetospheric particles at all spatial scales. Agreements between data providers, under the auspices of the IPY-ICESTAR and the GLObal RIometer Array (GLORIA) initiatives, and facilitated by the Global Auroral Imaging Access (GAIA) Virtual Observatory, will provide access to these data.

The ICESTAR team helped to develop the GAIA data portal. This virtual observatory deals with data from geospace optical and riometer systems. While the optical and riometer instruments differ in observational technique, both remotely sense

Christopher G Rapley, President 2006–08

Chris Rapley was born on 8 April 1947 and grew up in Bath where he attended King Edward's School. He read physics at Jesus College, University of Oxford, and then enrolled to do a Masters degree at the Jodrell Bank Centre for Astrophysics at the University of Manchester. He did not enjoy this and so, the following year, he obtained a place at the Mullard Space Science Laboratory at University College London (UCL) to study for a doctorate designing and making a payload for a satellite. It failed but, undeterred, he went on to design other innovative payloads that were not only successful but opened new horizons in research from satellites. His career at the Mullard Space Science Laboratory flourished as he progressed rapidly from lecturer, to reader, to professor and then Associate Director where he established and built up the Earth Observation satellite group. In 1994 he moved to Stockholm as Executive Director of the International Geosphere-Biosphere Programme of the International Council of Scientific Unions at the Royal Swedish Academy of Sciences. In 1998 he was appointed Director of the British Antarctic Survey (BAS) in Cambridge with the primary tasks of re-organising the Survey and improving its interdisciplinarity. His enthusiasm for Earth System Science proved an important driver here.

As Director of BAS he was also the UK Delegate to SCAR. At the XXV SCAR Delegates Meeting in Concepción, Chile, July 1998, he expressed strong reservations about the function and operation of SCAR that led to the Delegates agreeing to a major review of SCAR. He was elected as Vice-President of SCAR (2000–04) and President of SCAR in 2006. During this time he was Chairman of the Planning Committee for the International Polar Year, 2007–08. In 2007 he left BAS to become Director of the Science Museum in London and the following year he resigned as President of SCAR. He was elected an Honorary Member of SCAR in 2008. After four years at the Museum he returned to University College London where he is Professor of Climate Science, Chairman of the UCL Policy Commission on the Communication of Climate Science, and Chairman of the London Climate Change Partnership. He is a Fellow of St Edmund's College Cambridge, a visiting Professor at Imperial College London, a Distinguished Visiting Scientist at NASA's Jet Propulsion Laboratory in Pasadena, California, a member of the Academia Europaea, and a member of the European Space Agency Director General's high-level advisory committee on science strategy. His commitment to explain science to the public remains undiminished.

In 1999 he was made a Commander of the Order of the British Empire (CBE). In 2008 he was awarded the Edinburgh Science Medal "For professional achievements judged to have made a significant contribution to the well-being of humanity".

auroral precipitation. GAIA is a network-based set of tools for browsing summary data from All-Sky Imagers (ASIs), Meridian Scanning Photometers (MSPs), and riometers worldwide.

In 2004, SCAR signed a Memorandum of Understanding with the WCRP agreeing to co-sponsor the Climate and Cryosphere programme (CliC), the Southern Ocean Implementation Panel (already co-sponsored by CLIVAR and CliC), which was devoted to establishing a Southern Ocean observing system, and the International Panel for Antarctic Buoys (IPAB), which deploys drifting buoys on the sea ice. In turn, WCRP agreed to co-sponsor AGCS and its subgroups – ITASE and ASPeCt.

The Action Group on Modelling and Observational Studies of Antarctic Katabatic Winds (MOSAK) led by Azizan Samah (Malaysia), produced a new, improved high resolution near surface wind field for the Antarctic, of value in studies of blowing snow, sea ice advection and the investigation of katabatic winds. The group has since been absorbed into AGCS.

The REference Antarctic Data for Environmental Research (READER) Action Group led by John Turner (UK) continued to develop high quality data sets of key variables for investigating climate variability and change, and produced a new, improved database of mean Antarctic tropospheric/stratospheric temperatures, winds and heights from surface observations and radiosonde ascents. Meanwhile the Expert Group on Operational Meteorology led initially by Jon Shanklin (UK) and then by Steve Colwell (UK), provides a point of contact between many groups undertaking meteorological work in the Antarctic, ensuring that the amount of real-time data available from Antarctic sites increased, with data from several new Automated Weather Stations (AWS) now available on the WMO Global Telecommunications System (GTS).

Capitalizing on the use of Antarctica as a vantage point, SCAR established two astronomy groups in 2004–05: the Expert Group on Antarctic Astronomy and Astrophysics (AAA), and the Plateau Astronomy Site Testing in Antarctica Action Group (PASTA), both led by John Storey (Australia). In 2006 PASTA was dissolved, having achieved its objective in demonstrating that the Antarctic Plateau is the best place on Earth for surface-based astronomy. Delegates at XXX SCAR in 2008 approved the plans for the Astronomy and Astrophysics from Antarctica (AAA) Scientific Research Programme. The next steps will involve establishing four task groups:

1. Site testing, validation and data archiving;
2. Arctic site testing;
3. Science goals;
4. Major new facilities.

It was therefore fitting that the International Astronomical Union (IAU) was admitted to membership of SCAR as an ICSU scientific union member.

The joint SCAR/SCOR Oceanography Expert Group, co-chaired initially by Eberhard Fahrbach (Germany) and Eileen Hofmann (USA), began in Venice, in October 2005. The Group aimed to encourage an inter-disciplinary approach to Southern Ocean observations, modelling and research, recognizing the interdependence of physical, chemical and biological processes in the ocean at present and in the past; to facilitate co-ordination between the physical oceanographic research groups currently active and those planning research in the Southern Ocean; to identify historical and reference data sets of value to researchers, focusing initially on physical oceanography data; and to encourage the exchange of information with operational agencies. Since then it has developed plans for a Southern Ocean Observing System (SOOS).

In 2004-05 SCAR also co-sponsored with SCOR the international Antarctic Zone (iAnZONE) Project, chaired by Karen Heywood (UK), which undertakes physical oceanographic investigations around the Antarctic margins. During 2005, both iAnZONE and the SCAR co-sponsored Southern Ocean Implementation Panel

(SOIP) (chaired by Steve Rintoul, Australia), developed successful proposals for projects to be carried out during the IPY. The SOIP and IPAB provide the practical side of SOOS development, and so complement the work of the Oceans Expert Group. One of the SOIP's main achievements was the production of a document *A Vision for Climate Variability Research in the Southern Ocean–Ice–Atmosphere System* the results of which are feeding into the design of a Southern Ocean Observing System.

As another means of accessing information about climate change, Delegates in Hobart endorsed SCAR's co-sponsorship of the International Partnership in Ice Core Science (IPICS) (co-chaired by Eric Wolff (UK) and Ed Brook (USA)), which plans new palaeoclimate scientific research based on drilling long ice cores from the polar ice caps. During 2007, IPICS gained sponsorship from the IGBP's PAGES programme on past global change, and the International Association of Cryosphere Sciences (IACS). In 2008, IPICS became a SCAR Expert Group.

Developing the next generation of more realistic ice-sheet models requires a comprehensive and integrated approach based on targeted data collection and interpretation, and theoretical and numerical developments. The Ice Sheet Mass Balance and Sea Level (ISMASS) Expert Group began developing plans to work on these issues with the NSF-supported Center for Remote Sensing of Ice Sheets (CReSIS), led by the University of Kansas, and the Center for Interglacial Climate at the Niels Bohr Institute at the University of Copenhagen. A workshop on Improving Ice Sheet Models, organized by ISMASS and co-sponsored by SCAR, CReSIS, WCRP/CliC, and the IASC working group on glaciology, drafted a Science Plan outlining a community strategy for the next 5–10 years to address current inadequacies in prognostic ice-sheet models.

A new Action Group on Environmental Contamination in Antarctica (ECA), led by Roger Fuoco (Italy) and Gabriele Capodaglio (Italy), was formed at XXIX SCAR. It aimed:

a. to understand the mechanisms and processes controlling distribution and transport of micro-components in polar environments, and their environmental effects;

b. to assess the effects of global climatic changes on processes controlling the dispersion and transport of micro-components and to estimate the contribution of micro-components on climate and environmental changes in polar regions; and

c. to monitor the environmental characteristics in Antarctica and set up a database of environmental parameters to follow the environmental evolution in Polar Regions.

Analysis of the available data showed that a co-ordinated approach to contaminant studies across Antarctica is still lacking, and most studies have been restricted to the Antarctic Peninsula and the Ross Sea. ECA recommended that SCAR should consider establishing an internationally co-ordinated Antarctic Monitoring and Assessment Programme (AnMAP) (the equivalent of the Arctic Council's AMAP project) as well as making an inventory of all Antarctic Environmental Specimen Banks (AESBs) as the basis for setting up an information system.

The Polar Atmospheric Chemistry at the Tropopause (PACT) Action Group formed in 2008, under the leadership of Andrew Klekociuk (Australia) and Gennady Milinevsky (Ukraine) aims to improve understanding of the distribution and variability of ozone in the polar upper troposphere – lower stratosphere region, and the feedbacks of ozone changes to polar climate. Data will be made available through the Australian Antarctic Data Centre and the International Global Radiosonde Archive (IGRA).

The Action Group on Prediction of Changes in the Physical and Biological Environment of the Antarctic (PCPBEA) (Cross-SSG Group) was formed at XXX SCAR in

2008, and held its second meeting, at AWI, from 30 September to 2 October 2009. It aims to make a significant contribution to the 5th Assessment Report of the Intergovernmental Panel on Climate Change (IPCC). It will encourage: integration between biological and physical data gatherers and modellers; the development of long-term biological records that can be matched with long-term meteorological and oceanographic databases; and the development of biological models that can be combined with physical models of the Antarctic environment. It aims to produce a comprehensive paper comparing climate variability with biological variability, and recognizes the need to examine biological tolerance to change, and the effects of extreme events.

Standing Scientific Group on Geosciences (SSG-GS)

The SSG-GS was led by Chief Officer Phil O'Brien (Australia) in 2004, followed by Alessandro Capra (Italy) in 2004–12. It included two major Scientific Research Programmes (ACE and SALE), and a number of smaller Action and Expert groups. One of its major activities is the organization of the quadrennial meeting of the SCAR International Symposium on Antarctic Earth Science (ISAES). The 10th ISAES was held at the University of California, Santa Barbara, USA, in August 2007.

The Antarctic Climate Evolution (ACE) programme co-ordinates the integration of enhanced geological data and improved Antarctic palaeoclimate models for a series of time periods from the onset of glaciation around the Eocene-Oligocene boundary 34 million years (Ma) ago, to the last glacial maximum (LGM) 20,000 years ago. ACE is following up the work of the SCAR ANTIME project (part of the former SCAR GLOCHANT programme) that focused on the Antarctic environment during the Last Glacial Maximum. ACE was led initially by Martin Siegert (UK) and Rob Dunbar (USA), and from 2008 by Carlota Escutia-Dotti (Spain) and Rob De Conto (USA).

ACE has been especially active in organizing meetings. 'Glacial Sedimentary Processes and Products' in August 2005, at Aberystwyth, Wales, brought together researchers working on all aspects of glacial sedimentary processes and products in glaciomarine, glaciolacustrine and terrestrial settings, from Archaean times to the present day. At the same time another meeting in Calgary - 'The Last Great Global Warming: Proxy Reconstructions and Modelling the Pliocene Climate' addressed fundamental questions about the Pliocene world, including the biota, climate and environments, and the relevance of the period to the ongoing climate change debate. In September 2005 a workshop at Spoleto, Italy, addressed 'Cenozoic onshore and offshore stratigraphic records from the East Antarctic margin: recent results and future directions'. Finally a special session at the December 2005 AGU dealt with 'Antarctic Ice Sheet Evolution from the Last Glacial Maximum to the Holocene: Recent Advances from Modelling and Field Investigations', bringing together modellers and field-based researchers in terrestrial glacial geology and geomorphology, marine geology and geophysics, glaciologists and modellers.

Through the efforts of ACE and its predecessor programme ANTOSTRAT, it was understood that the onset of glaciation was not simply a response to the thermal isolation of Antarctica by the opening of the Southern Ocean between Antarctica and adjacent continents. Instead, recent numerical modelling suggested that declining atmospheric CO_2 was a more important factor in cooling Antarctica. Ice was, however, around before the mid-Cenozoic; marine sedimentary rock from Seymour Island provide indirect evidence, from what appear to be drop stones from icebergs, for extensive ice cover in Antarctica near the Cretaceous-Tertiary boundary 65 million years ago. Both Ross Sea drilling and Lambert Glacier studies confirmed that the ice margin advanced and retreated many times during late

Cenozoic times and into the Quaternary, confirming suspicions that fluctuations in the ice sheet reflect changes in insolation driven by changes in the Earth's orbit. ACE members undertook a field campaign led by BAS to map, describe, sample and photograph glacial sedimentary sequences and associated fossils on James Ross Island. By 2007, ACE was formally co-sponsored by IGBP's PAGES programme, and was also an IPY project. Aside from many papers in journals, ACE produced a Special Issue of *Palaeogeography, Palaeoclimatology, Palaeoecology* on Antarctic Climate Evolution, an overview of its work in the journal *Antarctic Science* and Florindo and Siegert edited a book for publication in 2011.

ACE was part of the 10th SCAR International Symposium on Antarctic Earth Sciences (ISAES), as well as providing a Special Session on Antarctic Climate Evolution at the 2007 INQUA meeting. ACE also continued to stimulate or be involved in geological drilling including a proposal to the International Ocean Drilling Program (IODP) for drilling in the Ross Sea. ANDRILL (Antarctic Drilling) Project (IPY Project #256), which ACE supported, completed its first drill hole beneath the McMurdo Ice Shelf in January 2007, reaching a record depth of 1284.87 metres below the sea floor. The recovered strata provided a record of ice shelf and climate history for the past 14 million years. ANDRILL's second season of drilling was completed in November 2007 to 1138.54 m beneath the sea ice of southern McMurdo Sound. The recovered strata overlapped with those from the first drill hole, and extended the record back to 20 million years.

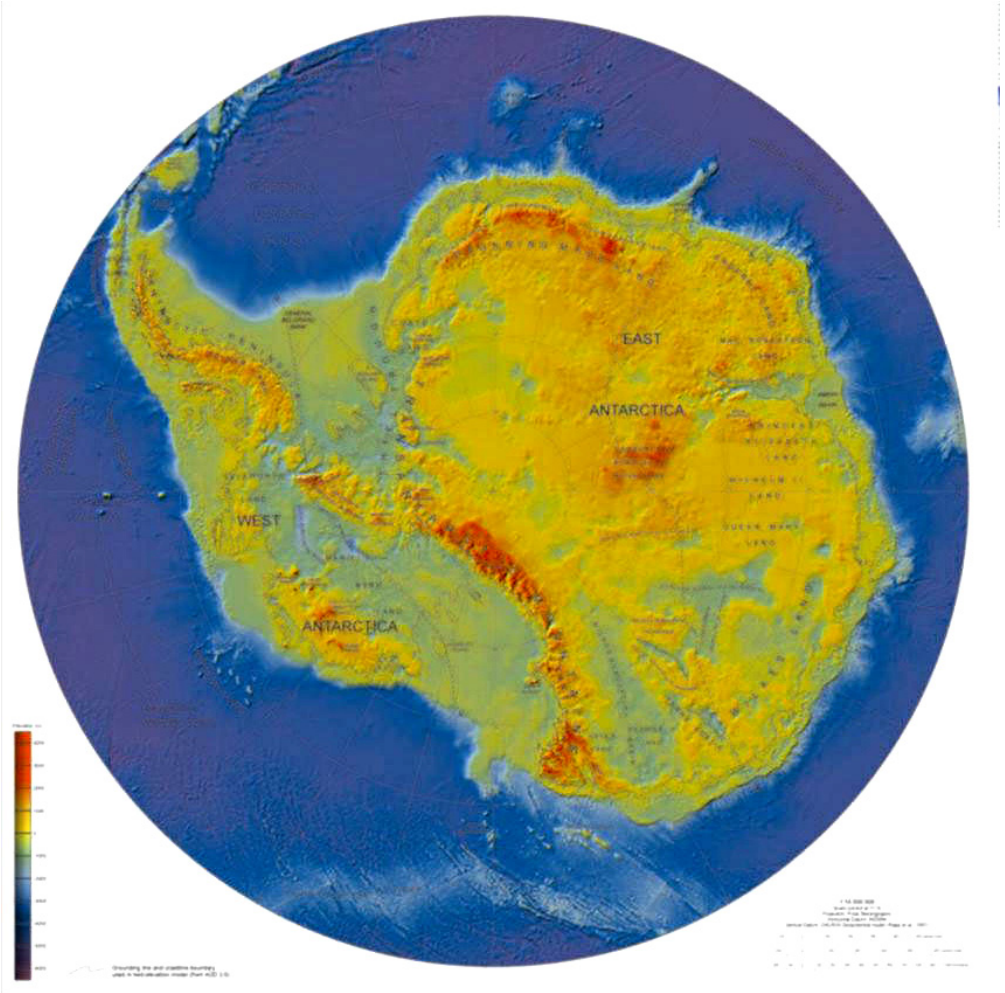
In 2008, ACE produced five key publications:

1. A Special Issue on *Antarctic cryosphere and Southern Ocean climate evolution (Cenozoic–Holocene)*;
2. The book *Antarctic Climate Evolution*;
3. A peer-reviewed review article "Recent advances in understanding Antarctic climate evolution";
4. A Special Issue, dedicated to Professor Bruce Sellwood, entitled *The Pliocene: a vision of Earth in the late 21st Century*;
5. *Cenozoic East Antarctic Ice Sheet Evolution from Wilkes Land Margin Sediments*, as an Integrated Ocean Drilling Programme Expedition 318 Scientific Prospectus.

ACE's main activity in 2008 was the organization of the First Antarctic Climate Evolution Symposium in Granada, Spain, attended by nearly 200 scientists from the fields of climate, ocean, and ice modelling, geology, geophysics and geochemistry. ACE was also active in organizing special sessions at EGU and AGU, as well as co-funding an Association of Polar Early Career Scientists (APECS) workshop in Spain.

The Antarctic Neotectonics Expert Group (ANTEC) was formed in 2004 from a former Group of Specialists. Neotectonics is the study of current deformations in the Earth's crust and this Group aimed to promote identifying 'target sites' for geodetic and seismic stations and promote field campaigns as well as co-ordinating the sharing of instrumentation, logistics, and data. Having developed a web-based resource of information on technological components required for autonomous remote observatories as well as an Antarctic Seismology Web Resource (AnSWeR), the Expert Group presented a thematic set of 21 papers on "Ice Sheets and Neotectonics" in a Special Issue of *Global and Planetary Change* in 2004. At XXX SCAR in July 2008 ANTEC was absorbed into the IPY POLENET Programme and SERCE (see below).

The Geodetic Infrastructure of Antarctica Expert Group (GIANT) was formed in 2008, to provide a common geodetic reference system for all Antarctic scientists and operators. It also contributes to global geodesy for studying the physical processes of the earth and the maintenance of the precise terrestrial reference frame, and provides information for monitoring the horizontal and vertical motion of Antarctica.



BEDMAP – Bed topography of the Antarctic.

Solid Earth Response and influences on Cryospheric Evolution Scientific Programme Planning Group (SERCE) aims to improve understanding of the solid Earth response to cryospheric and tectonic forcing, recognizing that neotectonic motion across Antarctica will occur due to displacements on active structures, deformation associated with active volcanism, and glacio-isostatic adjustment (GIA) of the Earth in response to changes in ice mass load. To obtain more accurate earth models for GIA predictions, we need to know how the physical properties and thermal structure vary laterally and with depth in the East and West Antarctic crust and mantle. Many of the necessary GPS measurements of crustal motion were made by POLENET for the IPY period. SERCE will provide the internationally co-ordinated approach to data analysis and synthesis needed to optimize the science outcomes of these new data sets. That will enable the GIA component to be removed from satellite signals that include a GIA component, so providing a more accurate picture of ice mass balance.

The International Bathymetric Chart of the Southern Ocean Expert Group (IBCSO) forms the steering group for production

of a revised chart of the bathymetry of the Southern Ocean, in conjunction with the International Hydrographic Organization (IHO), Intergovernmental Oceanographic Commission (IOC), and the General Bathymetric Chart of the Oceans (GEBCO). IBCSO expanded international collaboration in data collection and exchange and Germany was instrumental in providing new multi-beam data from several *Polarstern* cruises in Antarctic waters. IBCSO developed exchange of data with the RADARSAT Antarctic Mapping Programme (RAMP), Antarctic Bedrock Topography (BEDMAP2), Antarctic Digital Magnetic Anomaly Project (ADMAP), Earth Topography (ETOPO2), and GEBCO. In 2009, IBCSO organized a one-day meeting at AWI to discuss: the status of the bathymetric database provided by numerous institutions, data centres and individuals; the need to enlarge the network for a continuous data exchange; and the international collaboration needed in regions of poor bathymetry but high interest, such as the Amundsen Sea.

Created in 1995 under the auspices of SCAR and IAGA (International Association of Geomagnetism and Aeronomy) the Antarctic Digital Magnetic Anomaly Project Expert Group (ADMAP) is compiling national near-surface and satellite magnetic anomaly data into a digital map and database for the Antarctic continent and surrounding oceans. The unified data set will be a powerful tool for determining the structure, processes and tectonic evolution of the continent, together with providing information valuable in the reconstruction of the Gondwana and Rodinia supercontinents. ADMAP developed a DVD of the compilation of data up to 1999 for release to the World Data Centres; improved modelling of the Antarctic core field and its secular variations, developed an Antarctic Reference Model for improved magnetic anomaly determination; and worked on establishing a spherical harmonic cap model for the database to facilitate analytical manipulations of the Antarctic magnetic anomaly grid for geological applications. Work on the next compilation was underway with the intention of including more than 2 million line kilometres of new aeromagnetic and ship survey data since 2000, along with the German Challenging Mini-Satellite Payload (CHAMP) magnetic observations collected at altitudes of 300–325 km.

After some years of discussion a new Expert Group on Antarctic Permafrost and Periglacial Environments (EGAPPE) was agreed to provide co-ordination amongst Antarctic permafrost researchers and linkage with the International Permafrost Association (IPA) working groups. During 2004–05 EGAPPE prepared a white paper on the State of Antarctic Permafrost Science; prepared a map showing permafrost and ground ice features in the southern circumpolar region; and prepared maps showing soils of the southern circumpolar region. During 2006 EGAPPE developed an IPY project, Antarctic Permafrost and Soils (ANTPAS), to create a database for permafrost, and for active-layer monitoring within the framework of the Circumpolar Active Layer Monitoring-South (CALM-S). The Expert Group hosted a workshop in Santa Barbara, in August 2007 and in December a special issue of *Geoderma* produced by EGGAPE was published with the title *Antarctic Soils and Soil-Forming Processes in a Changing Environment*. EGAPPE published more than 50 papers on soils and permafrost in Antarctica, in the period 2005-2008.

During the 1990s considerable concerns were raised in several quarters about the potential effects of marine acoustic noise on marine mammals, particularly whales. One national environmental agency was proposing to prohibit not only all marine seismic research but also the use of a ship's echo-sounder, an essential item of safety equipment that is vital in the poorly charted waters around Antarctic coasts. This matter had been examined initially by GOSEAC and papers were tabled at ATCMs based on the results of two workshops. Following the re-organization of SCAR and the closure of GOSEAC, the new Geosciences SSG established an Action Group on Acoustics in the Marine

Environment to continue the work. The group held a further workshop which provided a major report for the CEP. Altogether SCAR provided seven papers to the Treaty on this subject. A particular innovation was the development of a system for structured risk evaluation of scientific instruments deployed in Antarctic research programmes, and a comparison with other acoustic activities known to affect marine life. The group concluded that ship noise levels in the Antarctic Peninsula region needed consideration because of the increased tourist vessel traffic but that there was no evidence that scientific equipment currently in use had anything but a transitory effect on marine life. These reports also provide scientific background information for national regulators responsible for issuing permits for marine surveys, and have been used by groups involved in the issues beyond the Antarctic (eg. US Marine Mammal Commission).

The Sub-Ice Geological Exploration Action Group (SIGE) was formed in 2006 and in 2008 was converted to an Expert Group with the acronym SIeGE. Its goals were: to evaluate and synthesize potential geological targets for subglacial sampling; to determine areas of high scientific interest to define targets for future surveying for geological sampling; to provide a forum

(a) to exchange ideas on potential geological targets and communicate plans of national and multinational campaigns for surveying and sampling, and

(b) for reviewing existing ice drilling and geological sampling technology and establishing plans for developing new technologies to achieve the desired surveying and sampling.

SIeGE will collaborate closely with ACE and SALE (above).

Cross-disciplinary Groups

The main objective of the Subglacial Antarctic Lake Environments (SALE) programme was to understand the formation and evolution of sub-glacial lake processes and environments; to determine the origins, evolution and maintenance of life in sub-glacial lake environments; and to understand the limnology and palaeoclimate history recorded in sub-glacial lake sediments. SALE also wanted to provide advice to governments on scientific and technology issues including addressing environmental concerns and proposing safeguards for sub-glacial environmental stewardship, exploration, research, and data management.

Subglacial water is central to many processes that have shaped the Antarctic continent and its ice sheets today and in the past. The processes that affect subglacial environments are mediated by the flow of the overlying ice, by the flux of heat and possibly fluids from the underlying rocks, and by hydrological processes that deliver water, materials, and heat to and through subglacial systems, dictating the residence times of water in lakes. This complex hydrological system constitutes one of Earth's last great unexplored frontiers and can be expected to contain clues to fundamental Earth and life processes.

The SALE Implementation Plan was approved during 2005, and a SALE Programme Office was established at Texas A&M University. The first SALE meeting was held in Vienna, Austria in April 2005. SALE was led by John Priscu (USA).

By the end of 2005, more than 145 subglacial lake features had been recognized, demonstrating that subglacial lake environments were widespread beneath Antarctica's ice sheets. Geophysical surveys identified additional large subglacial lakes whilst biogeochemical studies of Vostok Subglacial Lake accretion ice demonstrated that the lake environment varied over time frames of thousands of years suggesting these systems are dynamic. The age of Vostok Subglacial Lake suggested that its water has been cycled over 30 times possibly yielding total dissolved gas concentrations high enough to have important implications for drilling into the lake. The high oxygen concentration

(50 times more than air-equilibrated water) may pose a severe biological stress. Major scientific advances were summarized at the second SCAR SALE workshop (Grenoble, France, in April 2006). The workshop laid out plans for future SALE exploration and study, calling for a continent-wide campaign at multiple locations to map sys-tematically subglacial lake systems and their environs, and to enter, instrument, and sample ice, water, sediments, and potential microbiological residents. Outburst discharges of subglacial water have repeatedly occurred over geological time and are part of an on-going process that influences the dynamics of the overlying ice. Satellite altimetry of the ice sheet surface has shown that a portion of the central East Antarctic ice sheet lowered by 2–3 m between 1996 and 1997, at the same time the ice sheet was elevated 1–2 m some 250 km away. The only feasible explanation for this observation is the rapid loss of 1.8 km^3 of water from a subglacial lake, which flowed along the base of the ice sheet and into a series of other lakes. Similar observations have been made near the margins of West Antarctica. The expected pathways of subglacial water drainage were calculated, revealing a coherent network of channel systems, feeding water from large upstream catchments into several large outlets. Through these hydrological systems it is plausible that subglacial water can flow from the interior of ice-sheets to the ocean.

Subglacial aquatic environments occur in a range of geological settings suggesting that individual lakes may have differing origins and evolutions. Subglacial aquatic environments are not randomly distributed across the Antarctic continent suggesting that the limnological conditions, the age, the source of founder microbes, the time of isolation and the extant microbiological inhabitants will vary between locations.

By 2008, knowledge of subglacial aquatic environments had reached a level where major proposals were being submitted for funding by individual national programmes to sample directly the subglacial environment. The three proposals were:

1. Subglacial Lake Ellsworth: A combined UK–USA team will use hot water drilling to penetrate the lake's ice roof without contaminating the water body below. A probe will then enter the lake and collect measurements and samples. A 2–3 m sediment core will be taken from the lake bed.
2. West Antarctic Ice Streams: Proposals to the National Science Foundation include:
    - "Lake and Ice Stream Subglacial Access Research Drilling" (LISSARD) – to study lakes beneath Mercer and Whillans ice streams;
    - "Robotic Access to Grounding-zones for Exploration and Science" (RAGES) - to study nearby hydraulically-linked ice stream grounding zones.
    - "GeomicroBiology of Antarctic Subglacial Environments" (GBASE) - to study biodiversity and biogeochemical transformations within these systems.
3. Vostok Subglacial Lake: In 2007/08 the Russian Antarctic drilling programme above Vostok Subglacial Lake included drilling in borehole 5G-1, radio-echo sounding, and seismic studies.

From radio-echo sounding completed in January 2008 maps were made of the coastline of Vostok Subglacial Lake. Seismic studies of the water layer and of sediment rock thickness were also completed. During 2008–09, radio-echo sounding was conducted beyond the lake limits and preparations were underway to conduct seismic measurements of the geological structure of the Earth's crust. They now hope to enter the lake in the 2011–12 drilling season.

During the year, SALE provided a framework for developing a code of conduct for Antarctic subglacial exploration, and SCAR formed an Action Group to sub-

mit this plan to the Antarctic Treaty. By 2009, through the efforts of SALE, the international scientific community now recognized these environments as frontiers for scientific study across disciplines. Japanese scientists confirmed that liquid water was present at the base of the Dome Fuji ice core and that bacteria and other organic matter were present throughout the core. These biogenic particles were not correlated with the temperature or dust records in the core. Belgian scientists continued focusing on developing numerical models of ice flow over subglacial lakes, and studying the force and mass balance of large Antarctic glaciers and ice streams in combination with satellite radar interferometry, the influence of basal conditions on the dynamic behaviour of Antarctic glaciers and ice streams, and the palaeo-reconstruction of the glacial history of ice sheets.

The Seeps and Vents ANTarctica Action Group (SAVANT) was created at XXX SCAR in July 2008 to investigate biological communities associated with seamounts, cold seeps and hydrothermal vents, cold water coral and sponge communities. It will work closely with CCAMLR to identify areas likely to contain Vulnerable Marine Ecosystems around cold seeps and hydrothermal vents.

In the aftermath of the sinking of the MV *Explorer* on 23 November 2007, the Executive Committee decided to create an Action Group on Antarctic Fuel Spills (AGAFS) to address issues that might arise related to the fate and effects of fuel releases in Antarctica.

An Action Group on Prediction of Changes in the Physical and Biological Environments of the Antarctic was created to develop a research programme to capitalize on the results of the study of Antarctic Climate Change and the Environment.

Discussions about duplication of activities on King George Island had been going on for years. The Cross-SSG Action Group on King George Island (KGI) under the leadership of Sergio Marenssi (Argentina) was formed to improve communication and co-ordination between national operators and station managers but has found it difficult to make substantial progress.

Interactions with the Antarctic Treaty

As part of its reorganization, in 2004 SCAR replaced its Group of Specialists on Environmental Affairs and Conservation (GOSEAC), which was primarily responsible for the provision of scientific advice to the ATCM and its Committee on Environmental Protection (CEP), with a new Standing Committee on the Antarctic Treaty System (SC-ATS) having the same remit but fewer resources of people and finance. David Walton (UK), the former chairman of GOSEAC, chaired SC-ATS until 2006, when he retired and was replaced by Steven Chown (South Africa). The reduction in effort from GOSEAC to SC-ATS had been predicated on the likelihood that the CEP would by now take on much of the work formerly carried out by GOSEAC. This turned out to be a forlorn hope. Instead the steadily expanding work of the CEP has led to a significant increase in the number of requests to SCAR, at times threatening to overwhelm the resources available.

In 2004 in Cape Town at XXVII ATCM SCAR provided only a few Information Papers. One described the progress that SALE had made with investigating subglacial lakes, one on the criteria for designating Specially Protected Species, a third on evaluating the risks to cetaceans from noise created by seismic surveys and, on behalf of the IPY Committee, a paper on IPY progress.

It had long been part of SCAR's agenda to persuade Treaty Parties to apply the generally accepted IUCN criteria on species protection. SCAR's proposal to provide a "straw man example" for designating an Antarctic Specially Protected Species was well-received and provided a forum for discussing selection criteria and thresholds for designation. In response to enquiries, SCAR suggested that new data showed that Fur Seals no longer required

At XXVI ATCM in Madrid, Spain, June 2003, Anna Jones (UK) gave the first of the annual SCAR lectures to the ATCM. Anna Jones is delivering the lecture from her laptop computer, Jerónimo López-Martínez (Vice President of SCAR) is on her left and chaired the lecture; John Turner (Chairman of the SCAR SSG on Physical Sciences) is on her right.

special protection as the population now numbered in the millions, but the results so far on Ross Seals were inconclusive. SCAR was then asked to propose criteria for delisting a specially protected species (eg. Fur Seal and Ross Seal).

At XXVIII ATCM in Stockholm, in June 2005, SCAR used the IUCN approach to show what criteria and processes could be used to designate species as meriting special protection, suggesting that consideration might be given to the Macaroni Penguin and Southern Giant Petrel. The CEP endorsed the use of the IUCN criteria for assessing endangerment, agreed that any species assessed as Vulnerable or above should be assessed for listing, and accepted the new submission process and the guidelines for an appropriate Action Plan. SCAR was requested to submit cases for listing the Southern Giant Petrel and the Macaroni Penguin and for delisting Fur Seals. Despite enthusiasm from most Parties objections from a small number meant that the delisting had to wait a further paper the following year. SCAR was keen to provide advice on how

Robin Bell (USA), with Colin Summerhayes on her left, delivering the second annual SCAR lecture at the XXVII ATCM in Cape Town, South Africa, May – June 2004,

Biological Monitoring could help determine human impacts in the Antarctic, and presented a paper on Biological Diversity drawing attention to shortfalls in current approaches. This was, as it happens, closely linked to the SCAR Plenary lecture by Steven Chown, in the presence of HM King Carl XVI Gustaf of Sweden, on biodi-

versity. In its report to the Plenary SCAR described its re-organization and the new committee structure as well as drawing attention to the new programmes. Again SCAR submitted an Information Paper on behalf of the IPY Office reporting on progress. At XXIX ATCM in Edinburgh in June 2006, SCAR provided four Working Papers and six Information Papers; this compares with three Information Papers and two Working Papers in Stockholm, and five Information Papers in Cape Town, a measure of the increasing workload on the SC-ATS. Included were papers on the Giant Petrel and yet again on delisting Fur Seals. The advice to de-list was finally accepted after a lengthy debate which had as background the publication of an explosive edition of the *ECO* newsletter produced by the ASOC delegation at the ATCM. In this the UK was accused of persuading SCAR to propose delisting so that the killing of Fur Seals could recommence. Protestations from SCAR were strongly supported by the UK who condemned this as unacceptable behaviour by an accredited Expert, a point with which the meeting agreed. Agreement on the Giant Petrels paper was halted by new information arising from a recent meeting of the Advisory Committee on Albatrosses and Petrels which suggested that population figures might be inaccurate. In addition, SCAR agreed to provide an assessment of its status and trends for the Ross Seal. SCAR had also followed up its 2004 report on Marine Acoustics in the Southern Ocean in a further paper addressing the likelihood of damage to cetaceans from geophysical scientific surveys, which concluded that the likelihood of such damage was extremely small from the systems currently in use. At this meeting SCAR announced its proposal to undertake an assessment of Antarctic climate change and its effects, which met with enthusiastic support. In response to questions about the status of existing SCAR guidelines for terrestrial biological fieldwork, which were circulated for information, SCAR agreed to update them in consultation with SSG-LS and COMNAP.

SCAR provided three Working Papers and nine Information Papers for XXX ATCM in Delhi in 2007. Unfortunately, SCAR's advice on Giant Petrels had to be withdrawn when it was disclosed shortly before the meeting that a new and substantial source of unpublished data had been identified by the UK. SCAR disclosed the problem and outlined a solution in a "Non-Paper". As an immediate result the ATCM agreed a Resolution on the need for Parties to improve and exchange data on this species. SCAR's comprehensive review of the status of the Ross Seal, which was listed as 'Lower Risk, Least Concern' by the IUCN, concluded there were insufficient data to reach a sound conclusion, leading to the CEP accepting SCAR's recommendation that it remain a Specially Protected Species. The CEP also thanked SCAR for its paper on the Application of IUCN Endangerment Criteria at the Regional level of the Antarctic Treaty Area and proposed to add the SCAR guidelines to the CEP's own for managing Specially Protected Species. Several papers were presented on non-indigenous (invasive) species. SCAR's paper on hull fouling indicated that this provides an important route for the transport of marine non-native species to the Antarctic region, and drew attention to the need for research to understand the extent to which hull fouling could be reduced to prevent the introduction of non-native species. Australia and SCAR presented a paper on the IPY Aliens in Antarctica project. SCAR provided a paper on the "State of the Antarctic and Southern Ocean Climate System", which was Phase I of the review of Antarctic climate that SCAR had introduced at the previous ATCM. These reviews help to decide what observations needed to be made in future in the systems that are currently being designed to monitor the behaviour of the climate system and its effects, as the basis for understanding processes and underpinning forecasts of future change.

The Executive Director attended a conference on "Polar Regions: Challenges and Possibilities", organized by the UK Foreign

Office at Wilton Park Conference Centre, Sussex, UK, 1–4 October 2007. In the course of the meeting it became clear that some of the comments and criticism SCAR had been receiving at previous ATCM/CEP meetings stemmed from misunderstandings about SCAR's role in the Treaty system. Summerhayes explained that SCAR is not a governmental body, but comprises experts nominated by national academies who, even if they work for government agencies, are not there to represent their governments but to represent the science community in their country. The science carried out or fostered by SCAR scientists is for the most part about knowledge, understanding, and prediction; it is not about monitoring, for which SCAR has no remit, although at times SCAR science may monitor change over time as a means of determining the variability in the system. This made SCAR quite different from CCAMLR, another observer to the ATCM.

The EXCOM decided that SCAR's relationships with the Treaty Parties deserved careful examination to see how they might be improved. An *ad hoc* Action Group was formed under Clive Howard-Williams (NZ) to review the matter, in consultation with the chairman of the CEP (Neil Gilbert) and representatives of Treaty Parties along with Tito Acero, a representative of the Antarctic Treaty Secretariat. The Group concluded that SCAR's role as an observer and independent source of scientific advice was not widely understood by the continually changing representatives of the national delegations to the ATCM and CEP. Chief amongst the actions arising from this was the need to produce a paper explaining clearly to Antarctic Treaty Consultative Parties the limitations they needed to accept on SCAR's role in the Antarctic Treaty System. The paper, Information Paper IP07 at the ATCM in Baltimore in April 2009, explained SCAR's mission and its independence from government, and reminded Parties that SCAR does not conduct routine monitoring and reporting for regulatory or compliance purposes, but does encourage the collection of long-term observations of the environment for scientific reasons. It laid out the guiding principles under which SCAR provided accurate and robust advice and noted that it would rely almost exclusively on peer reviewed open access data as an assurance of quality. It was clear from the Baltimore meeting in 2009, that this paper went a long way towards disabusing Parties of the notion that SCAR was in some way a servant of the Antarctic Treaty System. One immediate consequence of these interactions was an invitation to the CEP Chair to attend meetings of the SCAR Delegates.

SCAR provided two Working Papers and five Information Papers to XXXI ATCM in Kiev in June 2008. Early in 2008 SCAR had convened a workshop of experts on the Southern Giant Petrel and concluded that according to the IUCN global criteria, the regional population south of 60°S is of Least Concern. The ATCM agreed that the data did not support the designation of the Southern Giant Petrel as a Specially Protected Species. SCAR's review of "Human Disturbance to Wildlife in the Broader Antarctic Region" noted that the effects of human disturbance are highly variable and that no single solution can be applied to managing human disturbance effects on wildlife. SCAR also noted with concern the decline in the numbers of long-term studies being undertaken and recommended that Parties encourage long-term work to help improve management of wildlife populations whilst noting that the site and species specific studies that are required as a basis for informed management decisions are largely lacking. The report was well-received. Following a discussion on the question of bioprospecting in the Antarctic Treaty Area, SCAR was asked to review recent published research that may involve bioprospecting, and to provide a survey of ongoing bioprospecting research within the SCAR community.

SCAR provided one Working Paper and nine Information Papers to XXXII ATCM in Baltimore in April 2009. These included

SCAR's revised Environmental Code of Conduct for Terrestrial Scientific Field Research in Antarctica, a summary of its Antarctic Climate Change and the Environment (ACCE) review, and papers on the IPY Aliens in Antarctica Project (from the Dutch perspective), the Alien Species Data Base, biological prospecting, and persistent organic pollutants (POPs) (the last as a major report for ATCM to transmit to the office for the Stockholm Convention on POPs). In addition SCAR presented its paper on SCAR's Role in the Antarctic Treaty. In the discussion on a work programme for CEP action on non-native species, SCAR pointed out that during its ongoing evaluation of terrestrial biodiversity it had become clear that there were major gaps in our knowledge of terrestrial biodiversity. SCAR plans to hold a conference on biodiversity to develop plans to tackle this problem. SCAR's advice on biodiversity resulting from that meeting will help Parties to rationalize the process of systematic conservation management. SCAR's climate report was very well received, and Parties decided to forward the SCAR climate paper to the Executive Secretary of the UNFCCC for consideration at its 51st meeting in Copenhagen (3–4 December 2009). SCAR agreed to bring regular updates on Antarctic climate change to future ATCM/CEP meetings.

Aside from these various papers of its own, SCAR had presented papers on behalf of the International Project Office for the International Polar Year (IPY) from 2004 onwards.

One of the major tasks of GOSEAC had been to review protected area Management Plans in detail for the ATCM, a task that was impossible for the reduced SC-ATS. Recognizing this difficulty, SCAR's EXCOM agreed in 2009 to assist SC-ATS by forming an Expert Group on Protected Area Management Plans (EG-PAMP).

Interactions with CCAMLR

SCAR is also an Observer to CCAMLR, although the relationship has tended mainly to comprise an exchange of information – mainly between SCAR and the Scientific Committee of CCAMLR. To ensure a closer relationship between the two organizations, SCAR appoints a representative to take the SCAR observer's seat at CCAMLR meetings in Hobart each October. From 2001 to 2005 this was Edith Fanta (Brazil), later replaced by Graham Hosie (Australia). By agreement with CCAMLR this person has usually also been asked to be the CCAMLR observer to biennial SCAR meetings, though from 2006 onwards the CCAMLR Executive Secretary was invited to attend SCAR Delegates' Meetings.

In 2005, CCAMLR was developing a proposal for an IPY project, a survey of Antarctic krill, and Graham Hosie was asked to co-ordinate between SCAR's CAML project and the CCAMLR one. This offered the prospect of discussions to develop common sampling protocols for Antarctic krill and other pelagic species that would meet the objectives of both CCAMLR and SCAR, and of using standard CCAMLR sampling protocols for krill during CAML surveys. CCAMLR noted that SCAR MarBIN and Southern Ocean Continuous Plankton Recorder survey database could help to address the objectives of CCAMLR's Ecosystem Monitoring Programme (CEMP) and it recognized that it needed to define what else it actually required from SCAR for its ecosystem monitoring and management programme.

Recognizing SCAR's interests in developing a closer relationship with CCAMLR, both Summerhayes and Hosie attended the 25th meeting of CCAMLR, in October 2006. Reciprocal memberships of committees were agreed and CCAMLR was invited to send representatives to the SOOS planning meetings, to the XXX SCAR Delegates' Meeting and Open Science Conference in 2008, and to the SCAR Biology Symposium planned for Sapporo in 2009. In return, SCAR had been represented on the CCAMLR workshop on Southern Ocean bioregionalization by Graham Hosie in September 2006.

Further developments to cement relations between SCAR and CCAMLR took place in 2007 with representatives from each organization participating in relevant workshops and meetings.

Whilst continuing to provide most of its advice to the ATCM and CCAMLR during this period, SCAR also elected, in 2008, to provide scientific advice to the Intergovernmental Panel on Climate Change (IPCC) on the role of the Antarctic in global climate change. SCAR currently reports to the IPCC through membership of the delegation of ICSU, which is recognized as an Observer to the IPCC.

Capacity Building, Education and Training (CBET) and Awards

The SCAR Strategic Plan 2004-2010 highlighted the need for SCAR "to develop scientific capacity in all SCAR Members, especially with respect to younger scientists, and to promote the incorporation of Antarctic science in education at all levels". This had begun earlier in 2002 when the prestigious Prince of Asturias (Spain) Prize of €50,000 was used to support five PhD/post doctoral level students in 2003–04, enabling them to visit and work with polar institutions in countries other than their own. This objective then formed the core of the US $30,000 per year SCAR Fellowship Programme, which has funded on average 4 students per year from the 2005–06 season onwards. Extra funds to support the fellowships have come from several countries.

There are other ways to build capacity. As a body of ICSU, SCAR is eligible to bid for ICSU grants. In 2007 SCAR was awarded €30,000 from ICSU in a joint bid with IASC, IACS and WCRP to fund a summer school on ice sheet modelling, whilst in 2009, SCAR was awarded €30,000 in a joint bid with IASC, to develop a set of 'lessons learned' from the IPY experience in engaging the public.

Since 2008, SCAR has been a co-sponsor, with IASC, of the Association of Polar Early Career Scientists (APECS), which is a worldwide association for undergraduate and graduate students, postdoctoral researchers, early faculty members, educators and others with interests in polar regions and the wider cryosphere. APECS grew out of the International Youth Steering Committee of the International Polar Year 2007–08, to stimulate and nurture the next generation of polar researchers. APECS' mission is to raise the profile of polar scientists by creating a network of polar researchers, developing new research directions and collaborations, providing opportunities for career development and promoting education and outreach to attract future generations of polar researchers. APECS was invited to send an observer to XXXI SCAR, and has nominated local representatives to attend SCAR science meetings.

At its 2005 meeting, the Executive Committee agreed to establish three SCAR medals to recognize excellence:

i. "The President's Medal for outstanding achievement in Antarctic science", to be awarded once in each SCAR Presidency to a candidate chosen by the President;
ii. "The SCAR Medal for Excellence in Antarctic Research"; and
iii. "The SCAR Medal for International Scientific Co-ordination".

The candidates for the last two would be chosen by the Delegates and SCAR scientists through a process of consultation, with awards being decided by the Executive Committee on the recommendations of an Awards Committee every two years. Awards would be presented during the biennial SCAR meetings (see Appendix 7). When the first awards were presented in Hobart the medals had unfortunately not arrived so the President made do with three large chocolate medallions wrapped in gold foil as an interim measure!

In 2004 SCAR began to award Certificates of Appreciation to individuals who had provided SCAR with outstanding service (see Appendix 7).

In 2009, SCAR undertook to manage the award of the new Martha T Muse Prize for

Science and Policy in Antarctica, on behalf of the Tinker Foundation (USA). This prestigious US $100,000 unrestricted yearly prize is presented to a mid-career individual in the fields of Antarctic science or policy who has demonstrated potential for sustained and significant contributions that will enhance the understanding and/or preservation of Antarctica. An international selection committee chooses the successful candidate. The first recipient was Professor Steven Chown (South Africa), Chief Officer of SCAR's SC-ATS programme, a former Chief Officer of the SSG on Life Sciences, and the SCAR Lecturer at the ATCM in Stockholm in 2005. The second recipient was Professor Helen Fricker, a glaciologist from Scripps Institution of Oceanography who has been instrumental in identifying the dynamic water bodies underlying the Antarctic ice sheet.

Communication

Antarctic science in many fields is now at the forefront of global science and highly relevant to policy development and decision-making by governments. While some countries (eg. China, Korea, India) are significantly increasing their investments in Antarctic research, others appear to be cutting back in response to pressures on funding. SCAR's Strategic Plan 2004-2010 called for a strategy for communication, published in 2006 as *SCAR Report* 25. This plan aims "to ensure a greater awareness of the valuable contribution of science to society, and improved mutual understanding between science and other sectors of society." But communication is not a subject just for the SCAR Secretariat. What is needed is a "culture of communication", in which all SCAR scientists see themselves as having a responsibility to communicate both between themselves and with the outside world, to ensure the success of SCAR's primary goals and objectives.

A core element of the Communications Plan is the biennial Open Science Conference (OSC), which attracted about 1000 people in Bremen, Germany, in July 2004, about 800 in Hobart, Australia, in July 2006, and more than 1,000 in St Petersburg in 2008. The OSC provides a wonderful opportunity for polar scientists to meet, to exchange ideas, to consider ideas for new programmes and to develop networks, as well as a chance to explain polar science to the media.

The biennial SCAR meetings, in which the OSC is embedded, provide further opportunities for communication, notably through the 2–3 day science business meetings of the SSGs and their subgroups, and the now 3-day long SCAR Delegates' Meeting, which follows each OSC. SCAR also organizes many smaller meetings and these include the major 4-yearly meetings of the Earth Scientists and the Biologists, which each attract around 300–400 participants.

SCAR has invested considerable effort in electronic communication, especially in an attractive and user-friendly web-site, launched in July 2004. Usage has risen steadily with an average of 143,000 hits and 81,600 downloads per month. This showcase for SCAR outputs needs continual upgrades to grow its audience further, and to lead with information on key issues, such as climate change, biodiversity, and ocean acidification.

Starting in 2004, SCAR rapidly moved towards a paperless operation, with almost all correspondence being handled by e-mail, and papers for meetings being provided electronically on the SCAR web-site rather than sent by mail. *SCAR Bulletins* and *Reports* are now also provided only on the web-site. Cessation of the flow of paper meant that the former full-time post of Administrative Assistant could be reduced to half-time, thus cutting both personnel and printing and mailing costs. Starting in 2004 SCAR began providing news via the web-site on Antarctic and polar science that is now assembled into a quarterly *SCAR Newsletter* to keep the community abreast of current developments. SCAR's main science programmes have each established electronic newsletters, as have the SSG for Geosciences, SCADM and MarBIN.

Also starting at the end of 2004 SCAR began providing an annual report of its activities. Annual reports are also provided to the ATCM and to the hosting organization for the Secretariat (Scott Polar Research Institute). The annual report features highlights of research results. From time to time these are now compiled into a report on SCAR's achievements. Achievements to 2006 are documented in *SCAR Report* 29. Reports on national activities have been streamlined and are posted on the SCAR web-site.

In July 2008, the incoming President, Chuck Kennicutt, inaugurated a series of monthly "Notes from the President", to inform the SCAR community about particular developments. These are supplemented by SCAR Circular Letters that inform or request action from National Committees and Delegates. For general information, SCAR now has a brochure, and various posters, and PowerPoint presentations on SCAR have been prepared and are available via the SCAR web-site.

To improve communications internally, Chief Officers of SSGs, SCADM and SCATS attend Executive Committee meetings and Delegates' Meetings, as *ex officio* members. To improve links and interactions between the SSGs and SRPs, Chief Officers of SSGs, SCADM and SCATS attend Cross-linkage Workshops. These have greatly improved the development of interdisciplinary approaches to Antarctic science, including the development of the ACCE report.

Reports of SCAR's major meetings are recorded in *SCAR Bulletins*. Action sheets from each meeting are combined to form the work programmes for the Secretariat, Delegates and EXCOM.

SCAR and IASC – a Bipolar Approach

IASC was formed in 1990 and in 2003 EXCOM decided that SCAR should seek to have a formal representative at IASC meetings, with a reciprocal invitation for IASC to be represented at SCAR meetings. A Letter of Agreement was developed, and duly signed in July 2006. Through it SCAR and IASC agreed to combine their efforts in selected fields to raise the level of impact of both organizations in terms of science and policy advice, as well as trying to avoid duplication. The association has proved successful, with SCAR and IASC working together to ensure a higher profile for the polar sciences in the post-IPY world. SCAR and IASC now co-sponsor the biennial High Latitude Climate meetings that take place every 2 years or so. In July 2008 they co-signed a Letter of Agreement on co-operation with the new International Association of Cryospheric Sciences (IACS) and a Memorandum of Understanding agreeing to co-sponsor the Association of Polar Early Career Scientists (APECS). In March 2009 they co-signed a Letter of Agreement with the International Permafrost Association (IPA), which was already a co-sponsor of SCAR's Permafrost science group. These agreements effectively bind together the main polar bodies of ICSU.

SCAR and IASC worked closely together as members (*ex officio*) of the IPY Joint Committee but the ending of the IPY begs the question of how SCAR and IASC may maintain the IPY legacy. To address that question, in January 2008 the two organizations formed the Joint IASC/SCAR Bipolar Action Group (BipAG), chaired by Heinz Miller (Germany) to advise both bodies on:

a. how best to develop collaborative bipolar activities in the future, and
b. how best to nurture the IPY 2007/2008 legacy.

SCAR and the IPY

SCAR began thinking about an IPY at its Tokyo meeting in July, 2000, where Karl Erb (USA) told Delegates that the COMNAP XII Meeting held during the previous week had agreed "to prepare for recognition of the 50th Anniversary of the International Geophysical Year in 2007-08". At XXVII SCAR, in 2002, Delegates supported the proposal that there should be an IPY programme to celebrate the 50th

anniversary of the IGY. Chris Rapley (UK) agreed to make enquiries to ICSU and IUGG and in due course he and Robin Bell (USA) presented a proposal for an IPY planning group in February 2003, whose case for establishing an IPY was accepted by the 88th Meeting of the ICSU Executive Board in February 2004, subject to confirmation by the ICSU General Assembly in 2005. Meanwhile, at the suggestion of Russia, the 14th WMO Congress in May 2003 had independently approved the idea of holding an IPY in 2007–08, and eventually in 2005 ICSU and WMO agreed to jointly sponsor the activity. At the Shanghai meeting, Delegates were reminded that 2008 was also the 50th anniversary of SCAR and Michael Stoddart (Australia) suggested that it was the right time for a written history of SCAR. The Delegates in Hobart unanimously agreed and this book is the result. Another was the Gala Dinner to celebrate SCAR's 50th Anniversary, hosted for the SCAR Delegates at the Academy of Sciences in Moscow in July 2008 and attended by Artur Chilingarov, the well-known Russian polar explorer and former Deputy Chairman of the Russian Duma.

The arrival of the IPY, which aimed to achieve an intensive burst of internationally co-ordinated, interdisciplinary, scientific research and observations focused on the Earth's polar regions from 1 March 2007 until 1 March 2009, was a fantastic opportunity for SCAR. Concealed in the opportunity was the challenge to SCAR to decide what role it would play in managing any legacy of data, systems or infrastructure arising from the IPY. SCAR faced the further challenge of responding to the IPY initiative with no extra human or financial resources. In response to a paper on IPY plans at XXVI ATCM, in Madrid in June 2003 the Parties adopted a Resolution calling for support in planning and implementating the IPY. ICSU approved the establishment of a Planning Committee for the IPY, with SCAR Vice President Chris Rapley (UK) as Chairman and Robin Bell as Vice-Chair. Eight other SCAR scientists were in the planning group of 2003–04: Ian Allison (Australia), Bob Binschadler (USA), Gino Cassassa (Chile), Steven Chown (South Africa), Vladimir Kotlyakov (Russia), Olav Orheim (Norway), Prem Pandey (India), and Zhanhai Zhang (China). In June 2004, Ian Allison agreed to be the official SCAR representative on the planning group. The new SCAR Executive Director Colin Summerhayes was tasked with representing SCAR's interests in IPY planning. In May 2004 the leaders of the SCAR Science Research Programmes agreed to adapt their programme plans to contribute to the IPY. When IPY formally commenced in March 2007 there were 228 endorsed programmes - 170 science, 57 in education and outreach and 1 in data management. Not all received final funding. Of the approved IPY science programmes, 97, or just under half of the total, were relevant to SCAR. Of these 97, 75 were in the natural sciences, 40% of them focused on the Antarctic and the rest being bipolar. 24 were SCAR-led, and another 27 involved SCAR science groups.

At its meeting in Bremen in July 2004, the SCAR EXCOM decided to form an *ad hoc* SCAR Advisory Committee on the IPY, chaired by Summerhayes:

a. to advise it on the SCAR input to the IPY Science Plan, on SCAR's role in IPY Implementation, and on the content of the IPY Implementation Plan;

b. to work with COMNAP to realize IPY objectives for the Southern Hemisphere;

c. to ensure that SCAR's Scientific Research Programmes were contributing to the IPY; and

d. to monitor the IPY process and to advise SCAR how its contributions to the IPY should develop.

COMNAP formed a complementary Coordinating Group for IPY preparations, a

Overleaf (pages 192–93): The IPY Planning Chart (the "honeycomb" diagram) of 230 research projects of the International Polar Year 2007–08.

chaired by Anders Karlqvist (Sweden), with which the SCAR group would liaise.

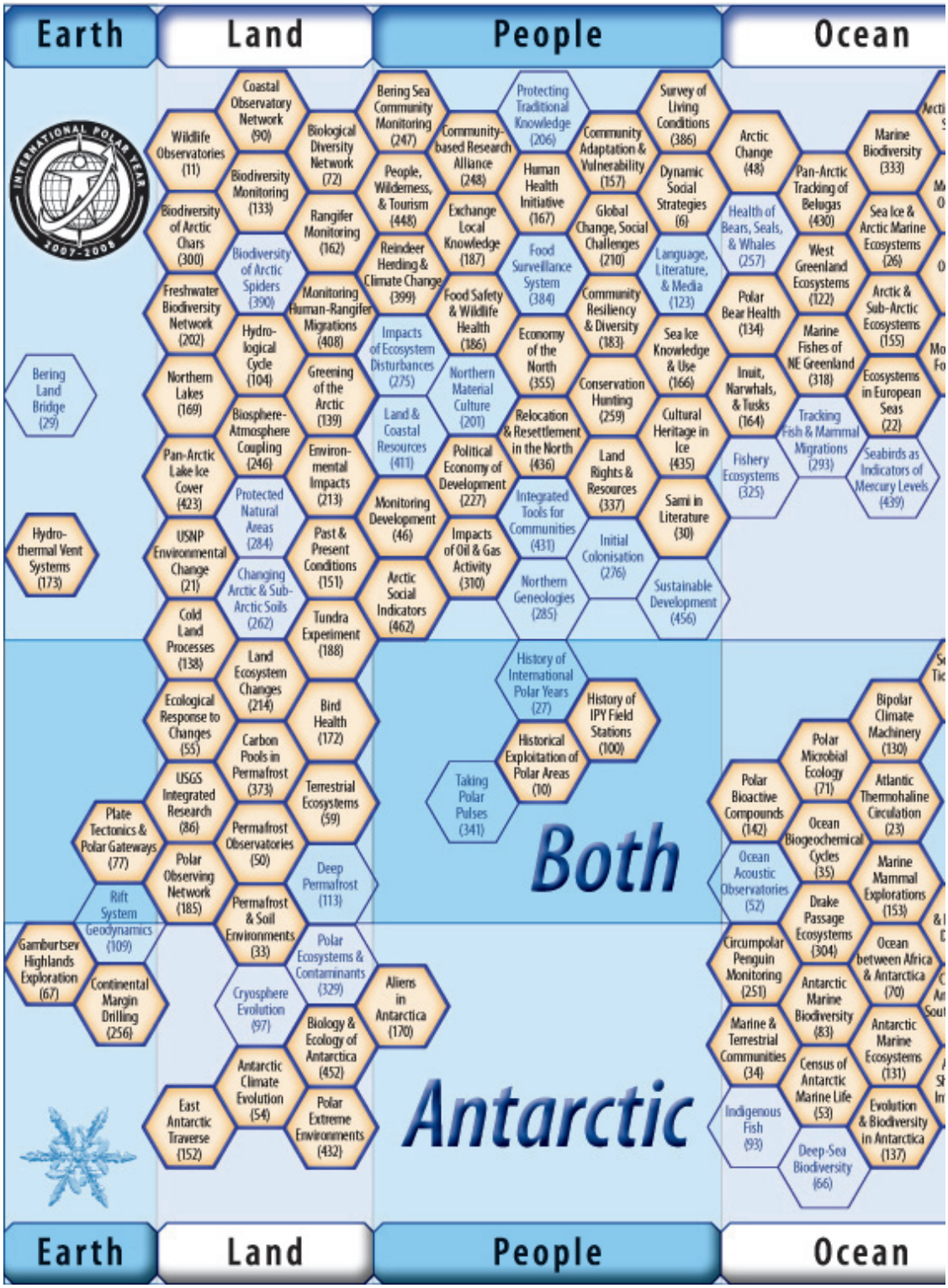
At the IPY Open Consultative Forum in Paris in September 2004, Summerhayes presented papers on "SCAR Comments on the IPY 2007-2008" and "Recommendations on data management for the International Polar Year 2007-2008". The SCAR 'Comments' paper was subsequently presented to the Delegates at XXVIII SCAR in Bremerhaven in October 2004. Delegates agreed with its recommendations that:

1. comprehensive data and information management should be an integral and essential part of the IPY legacy;
2. major SCAR programmes should be allocated a high priority for investment, with the highest priority being for subsets of these programme activities that require Special Observations during the IPY;
3. SCAR's Circum-Antarctic Census of Marine Life (CAML) programme would make a valuable IPY contribution;
4. the IPY offered an opportunity to develop an integrated Southern Ocean Observing System (SOOS);
5. the IPY offered an opportunity for a major bi-polar ice-drilling programme to provide essential input to climate models.
6. the IPY should take a geological perspective on climate change; 7. the IPY should support the Cryosphere Theme of the IGOS Partners;
8. the IPY offered the opportunity to focus geological attention on the subglacial highlands of the Gamburtsev Subglacial Mountains;
9. the IPY provided an opportunity for initial exploration of Antarctic subglacial lake environments.

When the call for expressions of intent in IPY activities was distributed by ICSU and WMO on 5 November 2004, SCAR ensured that all of its science groups were made aware that they should consider submitting proposals for IPY activities. On 10 November, SCAR suggestedto the Chairman of the Global Ocean Observing System's Scientific Steering Committee (J Baker) that GOOS should consider developing proposals for an Arctic and a Southern Ocean Observing System (SOOS), to meet the IPY Planning Group's requirement. This was supported by WMO but to no effect. Independently, SCAR directly stimulated the development of two IPY programmes serving the eventual needs of a SOOS – these were the Climate of Antarctic and the Southern Ocean (CASO) and the Synoptic Antarctic Shelf-Slope Interactions Study (SASSI) and, in partnership with SCOR, began developing a design plan for a SOOS. On 12 November 2004 SCAR

Top: Chris Rapley, Ed Sarukhanian (WMO), Valdimir Kotlyakov, unknown representative and Colin Summerhayes standing behind the Conference Cake at the SCAR–IASC Open Science Conference in St Petersburg, Russia, July 2008.

Above: The Conference Cake.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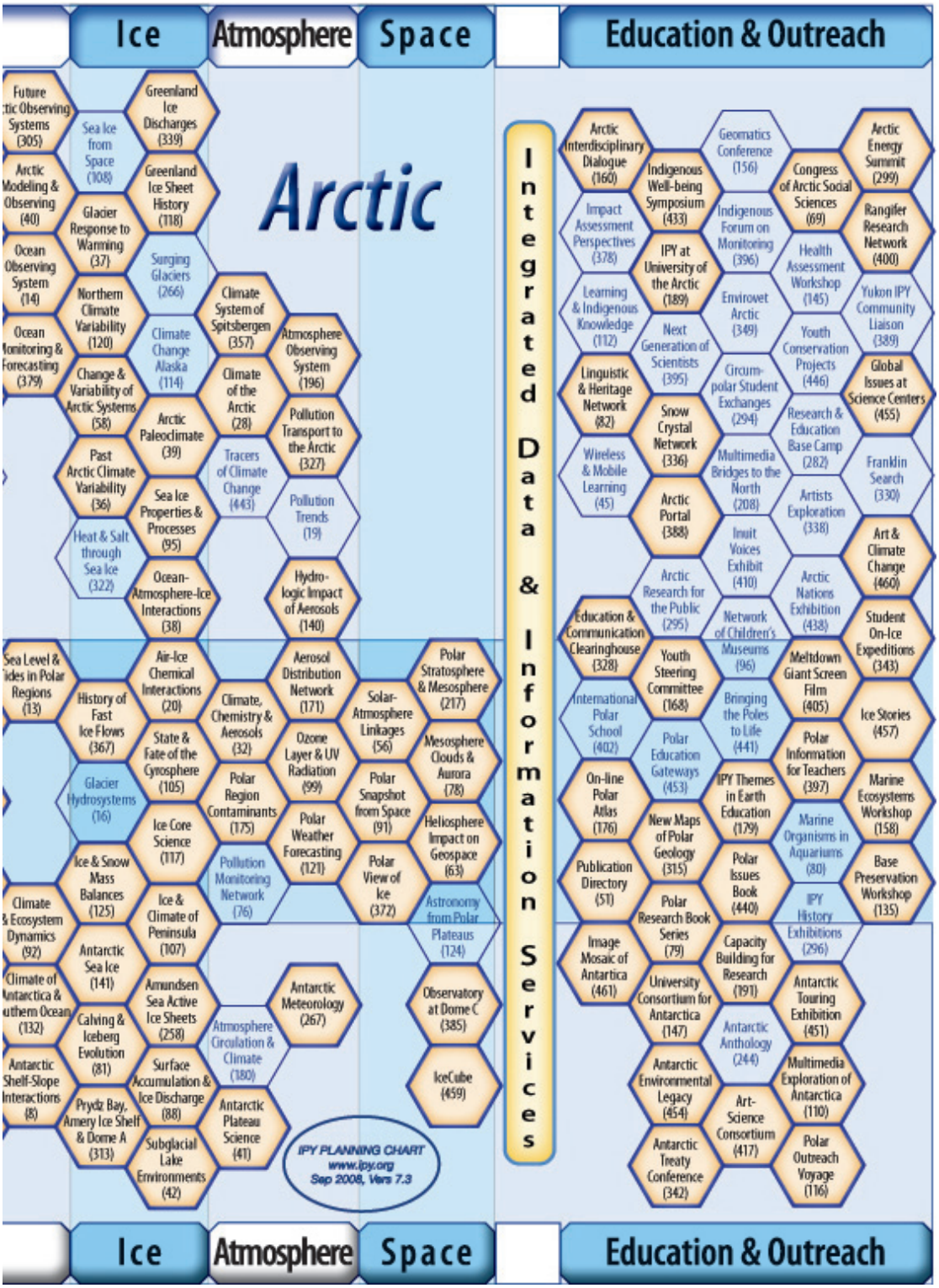
People
Ocean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The XXX SCAR Delegates' Meeting in Moscow, Russia, July 2008.

also encouraged the cryosphere community and WCRP to submit an expression of interest focused on the bipolar cryosphere plan being developed by SCAR and WCRP, which duly emerged as an IPY programme.

At the invitation of ICSU and WMO SCAR appointed Summerhayes as its representative on the ICSU–WMO Joint Committee for the IPY (the IPY–JC), which would steer the IPY process. With him on the IPY–JC were several SCAR scientists: Ian Allison (Co-Chairman) (Australia), Robin Bell (USA), Eberhard Fahrbach (Germany), Edith Fanta (Brazil), Jerónimo López-Martínez (Spain), Vladimir Kotlyakov (Russia), Chris Rapley (UK), and Takahashi Yamanouchi (Japan). The Chief Officer of SCAR's data committee (JCADM), Taco de Bruin, took on the role of Co-Chairman of the IPY Data Sub-Committee. On Summerhayes' retirement (April 2010) he would be reappointed to the JC *ad hominem* and SCAR would be represented by the President, Chuck Kennicutt, until the JC came to its end.

The IPY-JC agreed that the SCAR/IASC Open Science Conference in St Petersburg (2008) should be the first of a series of three IPY science conferences. The conference was co-sponsored by ICSU and WMO and organized by SCAR and IASC through a joint committee. Another similar organizing committee, under the chairmanship of Olav Orheim (Norway) was created to organize and manage the 2nd IPY science conference, which took place in Oslo in June 2010,

The SCAR Executive Committee during the XXX SCAR Delegates' Meeting in Moscow, Russia, July 2008. Left to right: Sergio Marenssi, Chuck Kennicutt, Chris Rapley, Colin Summerhayes, Toni Meloni, Jerónimo López-Martínez.

and Peter Harrison (Canada) and Karl Erb (USA) were appointed as co-chairs for the 3rd and final IPY science conference in Montreal in 2012, with SCAR being represented by the new Executive Director Mike Sparrow.

In recognition of the impact of the four IPYs on polar science, SCAR decided to launch its Open Science Conferences with the prestigious "Weyprecht Lecture" in recognition of Karl Weyprecht, the inspiration behind the first IPY (1882–83). The first Weyprecht lecture was delivered in St Petersburg in July 2008 by Robin Bell (USA) on the topic of the Gamburtsev Subglacial Mountains and the second in 2010 by John Carlstrom (USA) on astronomy from the Antarctic.

SCAR thus played a key role in the inception of the IPY and its international management. SCAR is expected to take a major role in managing the Antarctic legacy of the IPY, in much the same way that it had successfully managed the Antarctic legacy of the IGY. The key elements are included in the Strategic Plan for 2011–16. Improving Antarctic data and information management is a crucial feature of these and ICSU has created what it calls a Polar Information Commons (PIC) to develop this further.

Women and SCAR

Antarctic research had been an entirely male operation at the start of SCAR. Old

boys smoking pipes was an apt description of the meetings for the first two decades. Slowly women joined the national Antarctic operations, first in Australia in 1959 visiting Macquarie Island but it took another twenty years before they were working on the continent. In the USA female field scientists went to McMurdo Station in 1969. After that, slow but steady change occurred in other countries. There had been a few pioneer women at early biology symposia but they worked on samples brought back by male biologists, rather than doing their own field work. During the late 1970s women began appearing at SCAR meetings to present field science and then became national representatives on Working Groups and members of Groups of Specialists. For most countries equal opportunity eventually reached Antarctica in the 1990s.

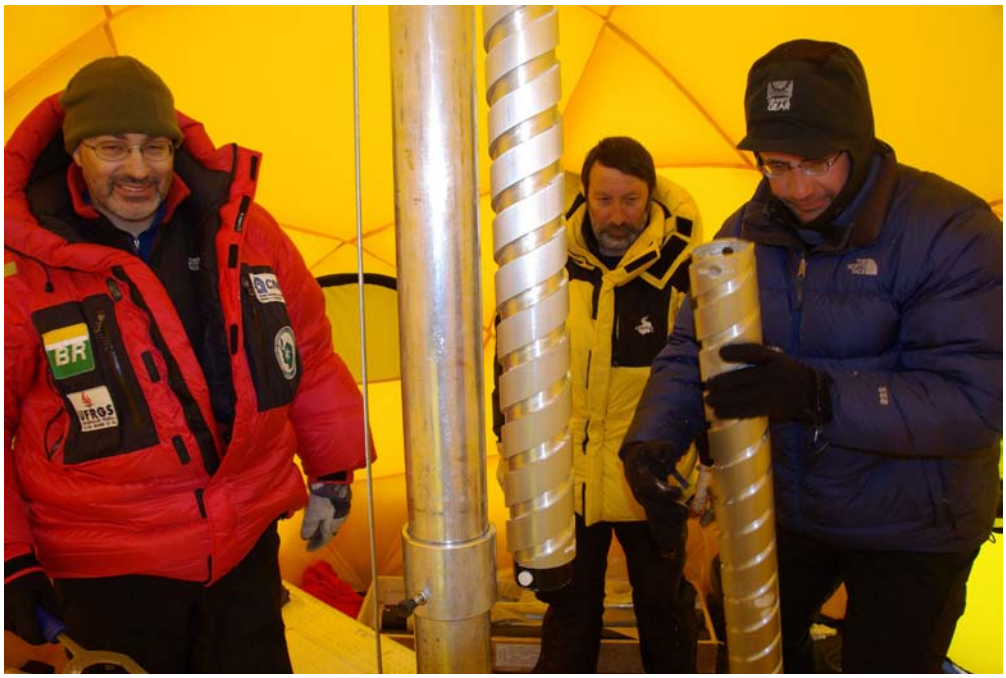
At SCAR Delegates' Meetings, Mlle Genevieve Pillet (France) proved the exception by representing URSI at XI SCAR in 1970 and for many years thereafter. However, it was to be a long time before there were female national Delegates at SCAR. Riita Mansukoski represented Finland as an Associate Member at XX SCAR in 1988 and was the Alternate Delegate at XXI SCAR in 1990 when Finland became a Full Member. Also at XXI SCAR, Ann-Christine Clottu-Vogel represented Switzerland as an Associate Member. In 2003 Terry Wilson was appointed as the first female Alternate Delegate from the United States and attended her first Delegates' Meeting in 2004. At that meeting, XXVIII SCAR, Lucia Campos was the Brazilian Alternate Delegate and Evelyne Gerber was the Swiss Alternate Delegate. Finally, in 2007 when Karin Lochte (Germany) was appointed Director of AWI she became the first female Delegate of a Full Member of SCAR at XXIX SCAR in 2008, 50 years after I SCAR! So far there have been no women on the SCAR Executive Committee but the gender mix at the SCAR Open Science Conferences would suggest that a female President of SCAR is only a matter of time.

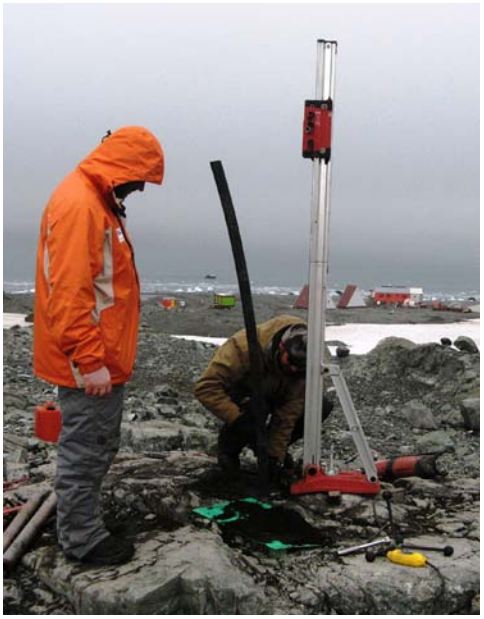
Ann-Christine Clottu-Vogel of the Swiss Academy of Sciences hosted the SCAR Executive Committee Meeting in Zürich, June 1991, and was presented with a copper planter by a grateful Executive. Left to right: Mrs Laws, Ann-Christine Clottu-Vogel, Claude Lorius and A Ohmura.

By contrast, women Managers of the National Antarctic Programmes represented their countries at COMNAP meetings from the early 1990s: Gillian Wratt (New Zealand) in 1992 and Carol Roberts (United States) in 1995.

Above: Left to right: Andrei Kurbatov, Fernando Reis, Jefferson C. Simões, Francisco E. Aquino, Ricardo Jaña, Heber P. Reis and Alexandre Alencar at Detroit Plateau on the Antarctic Peninsula. They are studying palaeoclimate and glacier response to environmental change as part of the joint Brazil–Chile–US "Antarctic and South American Climate" project. Photograph: CASA Project.

Below: Jefferson Simões (Brazil), Marcelo Arevalo (Chile) and Andrei Kurbatov (USA) with an ice core from the Detroit Plateau during the Brazil–Chile–US "Antarctic and South American Climate" project. Photograph: Jefferson Simões





Above left: The PERMANTAR project involved five countries. Here Alexandre Trinidade (Portugal) and Nikolai Koprinkov (Bulgaria) work on a drilling project. Photograph: Boiko Ganchev.

Above right: Colin Summerhayes, Executive Director of SCAR, at Neumayer Station, Ekströmisen, Dronning Maud Land, standing beneath the German and SCAR flags. Photograph: Peter Clarkson.

Below: The EPICA-Dome C camp near the French-Italian Concordia Station. The tall white dome (upper right of centre) is the drilling tent; the rectangular building (lower left of centre) houses the laboratories for analyzing the ice cores. Photograph: Italian Antarctic Expedition.

Top: A Russian Illyushin 76 at the Novo airstrip. The aircraft, operated by the Antarctic Logistics Centre International (ALCI), flies between Cape Town, South Africa, and Dronning Maud Land as part of the Dronning Maud Land Air Network (DROMLAN). Photograph: Peter Clarkson.

Below: The Argentine Navy provided the logistic support for the joint Argentine-US project "Investigating Iceberg Evolution during Drift and Break-up". In foreground automated instruments left on an iceberg. Photograph: Pedro Skvarca.

Above: Members of the International Trans-Antarctica Scientific Expedition (ITASE) taking a break in the space that serves as a radar control room, chemistry laboratory, and sleeping space for nine people. From left to right, Betsy Youngman, James Laatsch, Vandy Spikes, Gordon Hamilton, and Markus Frey. The ITASE programme uses shallow ice-cores to study environmental change over the past 200 years. Photograph: Dan Dixon / NSF.

Below: The South African SANAE Station on the top of Vesleskarvet Nunatak in Dronning Maud Land. Photograph: Peter Clarkson.

Above: Colin Summerhayes giving an interview to the Russian news media at Novolazarevskya station. Photograph: Peter Clarkson.

Below: An Argentine-US team testing an ice-radar on a small iceberg near Marambio Station (Seymour Island) within the joint project “Investigating Iceberg Evolution during Drift and Break-up”. Photograph: Pedro Skvarca.

Above: The United States Amundsen-Scott Station at the South Pole showing the main entrance to the station with the flags of the 12 countries that took part in the IGY 1957–58 (except that the flag of the Russian Federation has replaced that of the Soviet Union and those of South Africa and the United States are the modern flags). The glass globe on top of the striped "barber's pole" is the official position of the South Pole; the actual position of the South Geographical Pole, at 90° South latitude, is a short distance away.

Below: Chuck Kennicutt (in the white anorak), President of SCAR, visiting the Korean King Sejong Station on King George Island, South Shetland Islands.

Above: Moira Hassett, the SCAR Administrative Officer, at work in the SCAR corner of the General Office at the Scott Polar Research Institute. Photograph: Peter Clarkson.

Below: The Scott Polar Research Institute, Cambridge, United Kingdom, home of the SCAR Secretariat since 1958. Photograph: Peter Clarkson.