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International collaboration in Antarctica: the International Polar Years, the International Geophysical Year, and the Scientific Committee on Antarctic Research

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ABSTRACT. As the fourth International Polar Year (IPY) 2007–2008, gets into full swing it is timely to reflect on the history of development of international scientific collaboration in the IPYs since the first one in 1882–1883, including the third, which evolved into the International Geophysical Year (IGY) of 1957–1958. The success of international scientific collaboration in the IGY led the International Council for Science (ICSU), the body that managed the IGY, to create the Scientific Committee on Antarctic Research (SCAR) to carry forward the collaboration in Antarctic science that had begun during the IGY. This year, 2008, seems an appropriate time to undertake such an historical review, given that we are not only midway through the fourth IPY, but also that it is SCAR's 50th anniversary; the first SCAR meeting having been held in The Hague on 3–5 February 1958. Since SCAR's membership began with 12 member countries and 4 ICSU unions, membership has grown to 34 countries and 8 ICSU unions, with more expected to join at the 30th meeting of SCAR in Moscow in July 2008. Both SCAR's activities and those of the fourth IPY benefit from international collaboration not only between scientists, but also between the national Antarctic operations managers, working together through the Council of Managers of National Antarctic Programmes (COMNAP), and national policy makers working together through the Antarctic Treaty mechanisms. Thanks to all their efforts, the IPY of 2007–2009 will leave behind a legacy of enhanced observing systems for documenting the status and change of all aspects of the Antarctic environment as the basis for improved forecasting of its future condition. SCAR expects to play a major role in the design of those systems and their use to improve scientific understanding of the place of the Antarctic in the global environmental system, and the pace and direction of change within that system.

Contents

Introduction. Aspects of the development of international collaboration in science relevant to research in Antarctica

Scientists collaborate internationally in cases in which they are faced with challenges and questions that demand more resources of manpower, money and machines, and more intellect, than any one person or nation can supply. This is particularly true when investigating scientific questions that transgress geographical boundaries or are at the scale of whole ocean basins, whole continents, or the planet itself and its relation to other planetary bodies. It is also true where massive infrastructure or logistics is required, as in the European laboratory for particle physics, which is run by the European Organisation for Nuclear Research (known as CERN from its original French title, Conseil Européen pour la Recherche Nucléaire), and which began life in 1952, or the Deep Sea Drilling Project, now known as the Integrated Ocean Drilling Programme (IODP), which began life in 1969. And it is true where the investigation of particular topics demands an interdisciplinary approach, like those taken by the World Climate Research Programme (WCRP), or by the International Geosphere–Biosphere Programme (IGBP), a study of global change.

Of the many changes that swept over Europe in the 'enlightenment' of the late seventeenth and eighteenth centuries, the most widely influential was what is commonly referred to as the 'scientific revolution', which reflected a profound change in the way people thought about the world, and which led to rapid scientific and technological development. International collaboration in science grew initially through connections between individuals having common interests. By the nineteenth century international organisations were beginning to form. Apart from astronomy, scientists began to collaborate to study such global phenomena as the Earth's magnetic properties, and its weather, with the formation of the Göttingen Magnetic Union, a loose coalition of 44 continental observatories, by the great German astronomer K.F. Gauss, in 1834, and the International Meteorological Organization (IMO) in 1873. The national academies saw the benefit of collaborating beyond their borders and formed the International Association of Academies in 1899. That body was the forerunner of today's International Council for Science (ICSU), which was formed in 1931 and incorporated not only the academies but also a number of pre-existing international scientific unions, such as the International Union for Geodesy and Geophysics (IUGG), that was formed in 1919. Each union in turn comprised a number of international associations, like the International Association of Geodesy, formed in 1864, which became part of the IUGG. ICSU's acronym reflects its origin, when it was known as the International Council of Scientific Unions. Its role is to promote international scientific activity in the different branches of science, and its application for the benefit of humanity. As time went by, governments too began to cooperate in scientific endeavours through new inter-governmental structures like the World Meteorological Organization (WMO), which was formed from the IMO in 1950 and which became a specialised agency of the United Nations in 1951.

As we shall see later, IMO, WMO and ICSU were all important to the development of international scientific collaboration in Antarctica, as also were individual scientific unions such as the IUGG and programmes like the WCRP or the IODP and their predecessors. All of these organisations have (or in the case of IMO, had) a global scientific remit, within which are communities with special polar or Antarctic interests, like the International Association for Cryosphere Science (IACS), formed within IUGG in 2007, and the Scientific Committee on Antarctic Research (SCAR), an interdisciplinary body of ICSU that held its first meeting in February 1958. And it is as true now as it was 20 years ago to say that, 'What has been achieved in the name of science in the Antarctic region has been, and is being, achieved largely through international cooperation, between scientists and scientists, and governments and governments' (Fifield 1987). For the past 50 years ICSU's SCAR has played a lead role in making that achievement possible (SCAR 2007).

From the perspective of the historical development of Antarctic science, the most influential of all these bodies was the IMO, because it was the umbrella for the first and second International Polar Years, which greatly stimulated scientific research at both poles. Today, its successor, the WMO, continues that role, as a co-sponsor of the present IPY. The other big player, today a partner with WMO in the present IPY, is ICSU, the parent of SCAR. In what follows we shall see how their roles played out on the ice stage of the Antarctic.

The first and second International Polar Years

The idea of undertaking international scientific investigations in the Antarctic gained momentum following the British expedition of Sir James Clark Ross in 1839–1843 (Baker 1982a). The most influential of the proposals was that of the eminent American oceanographer Matthew Fontaine Maury, who had initiated a system to collect and collate meteorological and oceanographic observations from the ships of several nations so as to produce practical advice for sailors. In 1852 he suggested that a conference of meteorologists be held to extend his system, and the first International Meteorological Conference was duly held, in Brussels, in 1853. That meeting in turn planted the seeds for the first International Meteorological Congress, which was prepared in Leipzig in 1872, and held in Vienna, in 1873, and led to the later formation of the IMO, a non-governmental body that coordinated the collection and exchange of meteorological data and information, and stimulated research.

In the interim period, Maury had submitted in 1860, to the Secretary of the US Navy, a proposal for an Antarctic expedition. He followed that up in 1861 with a letter to several governments, to propose an international study of the Antarctic (Baker 1982b). At the time these suggestions did not receive positive responses, but they did not disappear. Maury had a disciple, in the person of the eminent German scientist Georg von Neumayer, creator of the Flagstaff Observatory for Geophysics, Magnetism and Natural Science in Melbourne, Australia, which he founded and directed from 1857 to 1864. Neumayer documented his Antarctic enthusiasms in his autobiographical treatise *Auf zum Südpol* (Neumayer 1901; see also Mill 1902, 1909). He subsequently co-founded the German Naval Observatory, the Deutsche Seewarte, in Hamburg, and served as its first Director, from 1876–1903. At the first International Geographical Congress, in Antwerp in 1871, Neumayer proposed that there should be an international Antarctic research study. He also tried to create enthusiasm for a German Antarctic expedition, but both ideas came to naught at the time. Later, in 1874, he put forward a proposal for studies in the two polar zones in order to resolve certain problems relating to the physics of the Earth (Lüdecke 2004). That proposal too came to naught, but the ground had been suitably prepared for what happened next.

Enter Karl Weyprecht, a young Lieutenant in the Imperial Austro–Hungarian Navy, and in those days we must remember that the Austro-Hungarian empire had a significant coastline on the eastern shores of the Adriatic with the consequence that most of its sailors were Croatians. In 1872–1874, Weyprecht had been the overall leader of the Austrian expedition that discovered Zemlya Frantsa–Iosifa [Franz Josef Land] in the high Arctic; his colleague, Julius Payer was responsible for the explorations on land. Their three masted vessel, *Tegetthoff*, became frozen in to the ice in 1872, leaving the young man plenty of time to think. Weyprecht's thoughts on polar exploration were to change the way that science was undertaken in the polar regions. As Baker (1982a, 1982b), Bell (2007) and others have pointed out, Weyprecht was acutely aware that insights into the fundamental problems of meteorology and geophysics were simply impossible for men hauling sledges across the ice and struggling to survive. His frustration at the inability to understand polar phenomena with the data from a single national expedition led him to propose that:

> Decisive scientific results can be attained only through a series of synchronous expeditions, whose task it would be to distribute themselves over the Arctic

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> regions, and to obtain one year's series of observations made according to the same method (Weyprecht 1875a: 33).

A new approach was needed, building on ideas already floating in the international scientific air (Baker 1982a, 1982b). Weyprecht next set down some 'Fundamental Principles of Scientific Arctic Exploration', which apply equally to the Antarctic (Weyprecht 1875b). He recommended that systematic and synchronous observations should be made in a coordinated way using the same basic instruments and the same methods at a set of observing stations spaced out around the Arctic region, and for a period of at least one year. The focus should be first on the various branches of physics and meteorology, then on botany, zoology and geology, and lastly on geographical detail, which was a matter of secondary interest. He thought that results of inestimable value would arise through establishment of comparable stations in the Antarctic.

Together with the sponsor of the *Tegetthoff* expedition, Count Wilczek, Weyprecht proposed that these principles be applied in an international polar programme (Wilczek and Weyprecht 1877). Their proposal was designed as a paper for the International Meteorological Congress of 1877, which eventually took place in Rome in 1879. Their goal for the expedition (which became the first International Polar Year) was:

> . . . to make, in the Arctic and Antarctic, or around those regions, and at as many stations as it may be possible to establish, synchronous observations following a programme decided upon in concert, so as, on the one hand, on proceeding through comparison, to deduce from observations collected at different points, independent of the particularities that characterise the different years of observation, the general laws governing the phenomena under study . . . . . (Wilczek and Weyprecht 1877: 1)

The investigations made in concert would address the phenomena of meteorology, terrestrial magnetism, the aurora borealis, and the realm of ice, and take place over one whole year. The two men specified the measurements to be made, and the instruments and methods to be used. For the southern hemisphere they recommended setting up stations in the Atlantic, Indian and Pacific ocean sectors, namely: close to Cape Horn, on Kerguelen or the MacDonald Islands, and on islands south of the Auckland Islands (presumably meaning Macquarie or Campbell).

The Congress approved the plan, recommended that governments support it, and instructed the international committee to convene a special conference to plan the expedition (IMC 1879). The first International Polar Conference duly took place in Hamburg on 1–5 October 1879, with Weyprecht in attendance (see details below). Thus began the deliberations that would lead to the first International Polar Year of 1882–1883, in which 12 countries launched 15 expeditions towards the poles, two of them to the Antarctic. Unfortunately young Weyprecht did not live to see his dream of international scientific collaboration in the polar regions fulfilled. Tragically, he died of tuberculosis in March 1881, aged 42 (Baker 1982a).

While Weyprecht was the architect of the IPY, it is unlikely that his ambitions would have come to fruition without the aid of Neumayer. As a senior German scientist, Neumayer had been a member of the International Meteorological Congress in Rome in 1879, at which Weyprecht had presented his ideas, and undoubtedly Weyprecht would have already been aware of Neumayer's published interest in the importance of research in the Antarctic. As we see from the congress record (IMC 1879: 85), during the discussion of Weyprecht's paper it was Neumayer who pushed for the inclusion of Antarctic stations, suggesting that polar meteorological stations be established at Kerguelen, the Auckland Islands and Punta Arenas. Neumayer played an important part in the Congress's decision to create the series of international polar conferences that were designed to plan the IPY (see Mill 1909; Lüdecke 2004), and which later became known as the sessions of the International Polar Conference (IPC). Given his prior interest in Antarctic exploration, we can be sure his powerful voice was heard.

In recognition of Neumayer's strong Antarctic interest and scientific eminence, the congress appointed him to chair the sessions of the IPC (Lüdecke; 2004, 2007a). The first session was held on home ground, at the Deutsche Seewarte in Hamburg in October 1879, and the second took place in Bern in August 1880, immediately prior to the meeting there of the International Meteorological Committee. Neumayer then resigned, apparently motivated by disappointment with the lack of official German support for an Arctic expedition. The chairmanship passed to Heinrich von Wild, who chaired the third and final conference in August 1881, in St Petersburg, where Wild was Director of the Central Physical Observatory. These three meetings converted Weyprecht's ideas into the implementation plan for the first IPY, a plan that also carries Neumayer's imprint. Nevertheless, Neumayer was careful to give Weyprecht full credit for proposing the notion and methodology for the IPY, which would run from 1 August 1882 to 31 August 1883.

Behind the scenes, Neumayer was also instrumental within Germany in persuading the government to provide two IPY stations, one in the Arctic and one on South Georgia. Later, in 1895, he created the German Commission for South Polar Exploration, which culminated in the first German Antarctic Expedition in 1901, the so-called German South Polar Expedition, aboard *Gauss*. Today Neumayer's name adorns the German polar research station in Dronning Maud Land.

With regard to the southern hemisphere, France set up an observing station at Bahia Orange, on the east coast of Isla Hoste, just north of False Cape Horn in Tierra del Fuego (Barr 2007: 539), and also published results collected with their help by a British missionary, Thomas Bridges, at Ushuaia, of which he was the founder (Baker 1982a). The French results were supplemented by the scientific work of their ship, *Romanche*. In addition,

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the French expedition brought back 17 crates of natural history specimens. *En route* to France the *Romanche* made a number of soundings in the Atlantic Ocean, in the process of which she made the deepest sounding recorded there, discovering the 7370 m deep Romanche Trench at 0°10′S and 20°03′W, close to the equator.

Germany sent an expedition to South Georgia, which set up a primary station at Moltke Hafen in Royal Bay, and a secondary station at Stanley in the Falkland Islands. Both the main German and French stations recorded anomalous tidal and pressure readings on 27–28 August 1883. These turned out to have been caused by the eruption of Krakatoa in the East Indies.

Nowadays there is much talk of the effect of industry on the carbon dioxide content of the atmosphere and its effect on climate. This concern is not new. It drove the French expedition to carry out a series of measurements of CO_2 concentrations in the atmosphere at Bahia Orange, which, at 256 parts per million (ppm), proved to be somewhat less than the 284 ppm measured in France (compare Baker 1982a, 1982b, and personal communication, January 2008)**,** presumably reflecting the relative lack of heavy industry in the southern hemisphere. Modern values are 100 ppm higher.

The first IPY set a new high standard for international scientific cooperation between nations as far as planning was concerned (Bell 2007), especially in the polar regions. But, while the organisers agreed that all of the results from the first IPY were to be published in standard form (Baker 1982a), they were less than successful when it came to working up the results. Sadly, as Baker (1982a), Lüdecke (2004) and Bell (2007) make plain, the gap between Weyprecht's vision and the outcomes was that most of the data were never integrated and analysed together in a timely fashion, although the auroral and magnetic data contributed to auroral theory, magnetic theory and the understanding of magnetic storms (Baker 1982a; Bell 2007). The meteorological data were too geographically sparse to analyse the dynamics of polar depressions, so were inadequate for weather or storm prediction. But they did provide the basis for a first climatology of the Arctic, and stimulated the production of early synoptic charts of the north and south Atlantic (Lüdecke 2004, 2007b). Under the leadership of Fritz Erk, Director of the Bayerische Meteorologische Centralstation in Munich, a PhD study was begun by Sebald Bernhard Ehrhart to integrate the meteorological data and to extract some meaning from the signals (Ehrhart 1902). Unfortunately he was unable to publish his work as anything other than his thesis in German, which meant that his findings were hidden in the grey scientific literature and were quickly forgotten. The full richness of the strategy was not widely realised therefore until scientists of the National Oceanic and Atmospheric Administration (NOAA) of the USA integrated the meteorological observations in 2006 (Wood and Overland 2006), indicating that during the first IPY the North Atlantic Oscillation had been very strongly developed and had contributed to the climatic variability of the Arctic. The deficiency in seeing that the results were processed in a timely fashion seems to have occurred because there was no international body to take responsibility for overseeing the necessary integration (Baker 1982a). That lesson had been learned by the organisers of the IGY, and has been thoroughly absorbed by those organising the fourth IPY. The polar commission of the time was more concerned with archiving the data than seeing that the science got done.

Despite its deficiencies, the first IPY was the first truly interdisciplinary international scientific programme, earlier international programmes having been concerned with only one discipline, like the astronomical expeditions of the eighteenth century to observe the transit of Venus, and the Magnetic Union of 1836–1841 (Baker 1982b). Nevertheless, although organised and coordinated under an international umbrella, the activities of the first IPY were in effect largely national activities working to a common international plan, with the exception of some bilateral programmes, such as those between the UK and Canada and Germany and Canada.

The expeditions of the first IPY were succeeded by a number of national expeditions stimulated by the International Geographical Congress of 1895, which made Antarctica the main target for new exploration. Of these, the first truly scientific expedition to the Antarctic was the Belgian Antarctic Expedition of 1897–1899 on *Belgica*, under the leadership of Adrien de Gerlache de Gomery. This was also the first scientific expedition to over-winter in the Antarctic, although not by choice, when *Belgica* became frozen in to the ice. Quite by chance this was also an unusually international expedition. Roald Amundsen, from Norway, was aboard, as first mate. Aside from the Belgian scientists there were Emile Racovitza, a Romanian naturalist, Henryk Arctowski, a Polish scientist acting as geologist, oceanographer and meteorologist, and his Polish meteorological assistant Antoine Dobrowolski, along with the American Frederick Cook, who later claimed to have reached the North Pole, as surgeon, anthropologist and photographer. The subsequent rash of national scientific expeditions forms the so-called 'heroic age' of Antarctic exploration between 1895 and 1917, featuring Borchgrevink, Scott and Shackleton (Britain), Nordenskjöld (Sweden), Charcot (France), Amundsen (Norway), Drygalski and Filchner (Germany), Bruce (Scotland), Mawson (Australia) and Shirase (Japan). The heroism came about as a by product of dealing with the hazards presented by penetrating the completely unknown and extremely hostile polar environments without the aid of maps or, in some cases, without any prior knowledge or experience of ice or polar conditions, something that would today be regarded as exceedingly foolhardy.

The idea for a second IPY, to commemorate the 50th anniversary of the first, was initially proposed by Leonid Breitfuss. He was a German representative on the German foundation, the Studiengesellschaft zur Erforschung der Arktis mit Luftfahrzeugen (or the International Society for the Exploration of the Arctic by means of Aircraft, otherwise known as AEROARCTIC), which was formed in 1924 with Fridtjof Nansen as president and many countries as members, to support an expedition in the airship *Graf Zeppelin* to the Arctic in 1931, with the objective of investigating the feasibility of trans-arctic airship routes. Breitfuss made his suggestion during the AEROARCTIC meeting of 16 November 1926, the minutes of which were published during 1927 (Berson and Breitfuss 1927). The meeting was also attended by Vice Admiral Hugo Dominik, the President of the Deutsche Seewarte, and Johannes Georgi, then a scientist at the meteorological research institute Gross-Borstel, the aerological station of the Deutsche Seewarte (Lüdecke, personal communication, February 2008). A year later on 23 November 1927, Georgi aired the idea at a meeting in the Deutsche Seewarte, in Hamburg, where it was agreed that a formal proposal should be made to the IMO. This may explain why Georgi is sometimes given credit for the idea (see Laursen 1959: 211; Baker 1982a). On reading Laursen's paper it is clear that he was not absolutely save of his facts concerning Georgi's formulation of the idea. We now know that Breitfuss was the originator. Later Dominik, the official representative of Germany to the IMO, made the official proposal, which was approved by the IMO in 1928, and by the General Assembly of the IUGG in 1930 (Baker 1982a; see also Laursen 1959). The association between these two organisations was a harbinger of the later organisation of the fourth IPY by ICSU (to which IUGG belongs) and WMO (the descendant of the IMO).

A new international polar commission was created to manage the process, and at its meeting in 1930, 26 countries agreed to participate in the IPY of 1932–1933 (Baker 1982b). The focus was to be on studying the extent to which observations in the polar regions could improve the accuracy of weather forecasts in other parts of the world, and how better knowledge of meteorological conditions at high latitudes would help sea and air transport. One reason for the timing was that this would be a period of low solar activity. The focus was on meteorology, magnetism, atmospheric science, and ionospheric physics, and investigating the global implications of the newly discovered 'jet stream'. Temperature, humidity and wind force were measured at high altitudes using the first radiosondes. The IPY greatly expanded the use of the new radiosonde balloons for measuring upper atmospheric properties, and they were widely used in the Arctic (Laursen 1959).

Unfortunately, less was achieved than had been hoped, because of the worldwide economic depression (Laursen 1959; Baker 1982b). Forty permanent observation stations were established in the Arctic, but according to Mills (2003: 321) only two operated south of 50°S, a British station on South Georgia and an Argentine station on Laurie Island in the South Orkneys. Brooks (1959) mentions these two, and adds a third station, at Ushuaia, operated by Argentina. All three appear to have been existing stations that supplied meteorological data. It appears from Laursen (1949: 46) that the Argentines were also making observations on South Georgia (see also Brooks 1959). It would appear from Brooks that other nations in the southern hemisphere (such as New Zealand) also contributed meteorological observations to the IPY, but the data pertaining to these other stations is sketchy. Reflecting the distribution of stations, it is not surprising that significant advances were made in meteorology and magnetism in the Arctic, but little was achieved in the south.

Financial difficulties retarded complete publication of the IPY results, and the outbreak of war in 1939 further curtailed the processing and publication of data. A so-called 'liquidating commission' was appointed after the war to complete as much of the work as possible by 31 December 1950 (Laursen 1951). The archives of the second IPY are stored by the Danish Meteorological Institute.

Bell (2007) includes the second Byrd Antarctic expedition of 1933–1935 as a US contribution to the second IPY of 1932–1933. It should not be, since although it sailed from the USA in 1933, it did not arrive in the Bay of Whales in the Ross Sea until January 1934. It is not included in the definitive list of second IPY projects (Laursen 1959; Baker 1982a, 1982b), nor is it formally claimed as an IPY contribution by the US second IPY committee (F.W.G. Baker, personal communication, February 2008).

The International Geophysical Year (IGY) 1957–1958

In April 1950, a third IPY was proposed by the eminent US physicist, L.V. Berkner. He recognised that 25 years after the second IPY would be an appropriate time to exploit the enormous progress that had been made in geophysics and in the development of scientific instruments as well as in such technologies as rockets and radar, to make huge scientific advances in the polar regions at a time of maximum solar activity (Baker 1982a; Jones 1959). The idea was transmitted to, and adopted by, ICSU, and then expanded to include the tropical region, and so became the International Geophysical Year (IGY), which would run from 1 July 1957 to 31 December 1958, later extended for an additional year (Zumberge 1987). This extra year was known as the International Geophysical Cooperation. ICSU created the Comité Special de l'Année Geophysique Internationale (CSAGI) to manage the IGY process, develop plans, and ensure publication of the results.

The IGY revolutionised scientific research in Antarctica by establishing a number of permanent scientific stations there (Table 1), which, in the case of the UK, built on stations established in the Antarctic Peninsula and the South Shetland Islands during World War II. Many of these bases are still in use today, though some (like the British station at Halley Bay) have had to be moved because they were established on moving ice shelves that would eventually drop them into the ocean. Massive logistical support from the US Navy in its Operation Deep Freeze led to the establishment of a station at the South Pole, in addition to McMurdo station on the Ross Island. Considerable logistical support also underpinned the success of the Commonwealth Trans-Antarctic Expedition, which crossed the continent by land for the first time from the Weddell Sea to the Ross Sea

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Table 1. Stations active during the International Geophysical Year (IGY 1967) (Bold = Established for IGY; after Mills 2003).

Country	Station(s)
Argentina	Almirante Brown, Esperanza, **General Belgrano**, General San Martin, Melchior, Orcadas, Primero de Mayo, Teniente Camara
Australia	**Davis**, Mawson, Macquarie (sub–Antarctic)
Belgium	**Roi Badouin**
Chile	Capitan Arturo Prat, General Bernardo O'Higgins, Presidente Gabriel Gonzales Videla, Presidente Pedro Aguirre Cerda
France	**Charcot, Dumont D'Urville**, Kerguelen (sub–Antarctic)
Great Britain	Admiralty Bay, Argentine Islands, Deception Island, Detaille Island, **Halley Bay**, Hope Bay, Horseshoe Island, Port Lockroy, Prospect Point, Shackleton, Signy island, South Ice, View Point, Stanley (sub–Antarctic), Grytviken (sub–Antarctic)
Japan	**Syowa**
New Zealand	**Scott**, Campbell Island (sub–Antarctic)
Norway	**Norway – Princess Martha Coast**
South Africa	**Gough Island**, Marion Island, Prince Edward Island, Tristan da Cunha (sub–Antarctic)
USSR	**Komsomal'skaya, Mirny, Oazis, Pionerskaya, Sovetskaya, Vostok, Vostok-I**
USA	**South Pole (later Amundsen-Scott), Byrd, Ellsworth, Little America V, McMurdo Sound (originally Williams Air Operations Facility), Wilkes (joint with Australia), Hallett (joint with NZ)**

Some coastal bases were points of departure for inland stations: McMurdo for South Pole station; Dumont D'Urville for Charcot; and Mirny for Pionerskaya, Komsomal'skaya, Sovetskaya and finally Vostok.

via the South Pole during the IGY, under the leadership of Sir Vivian Fuchs and Sir Edmund Hillary.

Altogether some 5000 scientists and support personnel were engaged (Stonehouse 2002). Between them they produced large volumes of data (Mills 2003). IGY information and results filled 48 volumes of the Annals of the International Geophysical Year between 1957 and 1967 (Fogg 2007: 535–536). Summaries of the initial advances made during the IGY were published in the Annals for 1967 by Gould (overall effects), Holdgate (biology), Lambert (cartography), Willett (geology), Nagata and Oguti (upper Atmosphere), Astapenko and Treshnikov (meteorology, oceanography and glaciology), and Woollard (continental structure) (see bibliography for detailed references).

The application of advanced technologies led to major scientific advances in a wide range of fields (Baker 1983). Some 60 weather stations linked to Antarctic weather centres, such as those at Little America, Mirny, McMurdo and, later, the International Antarctic Analysis Centre, Melbourne (Astapenko and Treshnikov 1967), were established in the Antarctic and the sub–Antarctic, making possible the first synoptic studies of the region and enabling atmospheric scientists to model more effectively the behaviour of the whole atmosphere. They were also able to investigate the ionosphere. Explorer–I, the first US space satellite (officially known as Satellite 1958 Alpha), was launched on 31 January 1958 and used instruments designed by James Van Allen to discover the high intensity radiation belts now called the Van Allen Belts. The discovery was confirmed by Explorer–III (known as Satellite 1958 Gamma), launched in March 1958, and counts as one of the major discoveries of the IGY. According to M. Nicolet, the high intensity radiation belts were observed by the Russian satellite, Sputnik, which had been launched in October 1957, but the results were not published (F.W.G. Baker, personal communication, February 2008).

It is not widely remembered that the USA carried out three secret nuclear explosions in the atmosphere in the southern hemisphere in 1958 as part of Operation Argus during the IGY. Operation Argus was the only clandestine test series in the 17 year history of atmospheric testing. It took place approximately 1760 km (1100 miles) southwest of Cape Town, South Africa, and consisted of three very high altitude test shots of the W–25 warhead to investigate the effects of nuclear explosions outside the atmosphere, in particular how the charged particles and radioactive isotopes released would interact with the Earth's magnetic field. The aim was to find out how such explosions might interfere with radar tracking, communications, and the electronics of satellites and ballistic missiles. The tests took place between 27 August and 1 September at heights of 160 km at 38°S 12°W, 290 km at 50°S 8°W, and 750 km at 50°S10°W (Sullivan 1961: Chapter 8). All were over 2000 km north of the Antarctic coast. It was not long before the operation was declassified, and it was reported on soon after the IGY in books by *The New York Times* science correspondent and IGY participant Walter Sullivan (Sullivan 1961) and IUGG president Tuzo Wilson (Wilson 1961). Indeed, the discipline of nuclear radiation was added to those of the IGY in part because of the operation (F.W.G. Baker, personal communication, February 2008.

The introduction of the all-sky camera, supplemented by visual observations from many ground stations, enabled Y.I. Feldstein in the USSR to show that aurora appear in a doughnut-shaped band around the polar

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regions (Feldstein and Starkov 1967). Compared with the previous IPYs, the IGY led to a massive increase in glaciological observations, especially from Antarctica, where studies were made of the thickness and development of the ice sheet. During the IGY considerable numbers of observations of oceanography were made in the Southern Ocean and elsewhere.

The IGY legacy comprises not only the solid infrastructure, the stations and their measuring equipment, but a subsequent veritable explosion in geophysical studies (Baker 1982a, 1982b). These can be grouped into three main areas; solid Earth geophysics; Sun-Earth interactions; and atmospheric sciences.

In geophysics, there was the World Magnetic Survey (1957–1869), which led to publication of the new World Magnetic Map in 1965. The Upper Mantle Programme (1962–1968) continued IGY studies of the outer 100 km of the Earth, including special regions like continental margins and rift valleys. It evolved into the International Geodynamics Programme (1970–1979), with an emphasis on the dynamics and dynamic history of the Earth, and then into the International Lithosphere Programme (established in 1980 and still extant), to provide an evolutionary history of the continental lithosphere. These programmes provided information about the Earth's mineral and energy resources and could be applied to assessing, predicting and mitigating geological hazards such as earthquakes, volcanic eruptions, tsunami and landslides.

Studies of solar–terrestrial interactions continued through such programmes as the International Year of the Quiet Sun (1964–1965), and the International Solar Maximum Year (1979–1981).

The IGY could also be said to have stimulated development of a similar series of programmes in the field of atmospheric research, though with some delay while the key technologies (satellites and computers) evolved (Baker 1982b). In 1962, the WMO began undertaking studies to advance research in atmospheric science, closely followed by ICSU, which in 1964 created a Committee on Atmospheric Science. In 1967, ICSU and WMO launched a joint programme, the Global Atmospheric Research Programme (GARP) to improve understanding of the general circulation of the atmosphere and to increase the accuracy of weather forecasting.

One of the legacies of the IGY lay in the belated recognition of the importance of international biological studies, which led in 1959 to the idea of an International Biological Year (Baker 1982a). The IBY eventually took shape as the International Biological Programme (1964–1974). It partly overlapped with, and was succeeded by, UNESCO's Man and the Biosphere (MAB) programme, which was launched in 1971 (Baker 1982b). These studies continued in some sense, the biological studies that had begun during the first IPY, especially those undertaken by the French at their Cape Horn station, although natural history specimens were also collected by the Germans at South Georgia and by Austrians, Germans, Russians and Americans in the Arctic (Baker 1982a).

To deal with the enormous volume of data in many different disciplines of science, ICSU created the World Data Centres, which still continue to this day.

The IGY brought together many thousands of men and women from all over the world to take part freely in a common undertaking (Baker 1983). It was organised by scientists, yet supported by governments. It was a civilian exercise, yet logistically supported in some countries, notably the USA, by the armed forces. It was watched over and coordinated, but not organised, by an international institution, yet relied on the collaboration of scientists from 67 countries. Despite its apolitical nature, its cooperative spirit contributed in no small way to the diplomatic framework for later negotiations leading to such developments as the Antarctic Treaty (1961), the Test Ban Treaty (1963) and the Space Treaty (1967) (Baker 1982b).

Aside from all this, the IGY also sparked the imagination of the public and politicians alike, and drew their attention to the need for greater knowledge about our immediate environment (Baker 1983). Perhaps the greatest of these impacts came from the launch of the very first satellite, Sputnik-1, by the Russians on 4 October 1957, that stimulated the space race and the US Moon programme.

During the IGY, ICSU recognised the need for a number of bodies to continue the work of coordinating and facilitating research beyond the end of the observing period. Three so-called special committees were created to continue the work in oceanic research, space research, and Antarctic research. Today these three are interdisciplinary bodies of ICSU, the Scientific Committee on Oceanic Research (SCOR), the Committee on Space Research (COSPAR), and the Scientific Committee on Antarctic Research (SCAR), to which we now turn.

The Scientific Committee on Antarctic Research (SCAR)

SCAR was born of the desire of scientists to continue the international coordination of Antarctic research after the IGY, and it held its first meeting in The Hague on 3–5 February 1958. The committee was charged with furthering the coordination of scientific activity in the Antarctic, with a view to framing a scientific programme of circumpolar scope and significance. From the beginning, then, SCAR's mission has been to facilitate and coordinate Antarctic research, in particular pan-Antarctic research of a scope beyond that of its individual national members.

What this means in practice, following SCAR's reorganisation in the year 2000, is a focus on initiating, developing, and coordinating high quality international pan-Antarctic scientific research in the Antarctic region, and on the role of the Antarctic region in the Earth system (SCAR 2004). To help to make this pan-Antarctic approach succeed, SCAR works with its members to facilitate free and unrestricted access to Antarctic scientific data and information.

Table 2. The national members of SCAR in spring 2008.

Argentina	Australia	Belgium	Brazil	Bulgaria
Canada	Chile	China	Denmark	Ecuador
Finland	France	Germany	India	Italy
Japan	Korea	Malaysia	Netherlands	New Zealand
Norway	Pakistan	Peru	Poland	Portugal
Russia	South Africa	Spain	Sweden	Switzerland
Ukraine	UK	USA	Uruguay	

SCAR also recognises the need to reach out to the wider community of policy makers, science students and the general public. In this context, SCAR is first and foremost an official observer to the Antarctic Treaty, which is another product of the IGY. SCAR provides objective and independent scientific advice to the annual Antarctic Treaty Consultative Meeting (ATCM) and related organisations on issues of science and conservation affecting the management of Antarctica and the Southern Ocean. On a wider front, SCAR has begun helping to develop the scientific capacity of all its members, especially their young scientists, notably through the SCAR fellowship programme and the biennial open science conference. SCAR is also keen to promote the incorporation of Antarctic science in education at all levels, and to communicate scientific information about the Antarctic region to the public, notably by means of the internet.

As a body of ICSU, SCAR is funded by national academies of science affiliated to ICSU. Because it is not an intergovernmental body, SCAR's agenda is nominally independent of national aims. Nevertheless, much of what SCAR does in practice is facilitated by national operators and both uses and adds value to the activities of national programmes. Indeed, many of SCAR's scientists may be government scientists working alongside those from academia. Because it has no governmental remit, SCAR is not charged formally with monitoring and reporting. But, in the interests of science it may decide to monitor some aspect of the environment for the purposes of establishing trends and understanding processes, and to report on its results to appropriate authorities.

In 1958, SCAR had just 12 member countries and 4 ICSU scientific unions (IGU, covering geography and glaciology, IUBS for biology, IUGG for geodesy and geophysics, and URSI for radio science, meaning all aspects of electromagnetic fields and waves). That was the case for 20 years until Poland and the Federal Republic of Germany joined in 1978. By 2008, SCAR had 34 member countries (Table 2) and counted among its members 8 of ICSU's scientific unions, the additional four being IUGS for geological sciences, IUPAC for chemistry, IUPS for physiological sciences, and INQUA for Quaternary research.

SCAR's work is carried out through groups of like minded scientists who make a case for support for a certain period to work on a particular pan-Antarctic issue. Its working practices (SCAR 2004) have evolved since they were last publicly reviewed by Zumberge (1987). Action groups address specific matters with a narrow remit and will normally complete their activity in 2–4 years. Expert groups address matters on a longer time-scale. SCAR's main focus is on a limited number of major scientific research programmes that address significant topical issues over a 5–10 year period. They should make significant advances in our understanding of how the Antarctic region works, and its role in the global system: for instance: documenting past change; detecting present change; evaluating environmental effects; attributing causes; and improving the ability to forecast future trends. SCAR provides the major programmes with seed corn funds to facilitate the meetings and workshops needed for them to succeed. All three kinds of groups are 'bottom-up', emerging from within the scientific community. Table 3 lists the groups current in 2008, prior to the XXX SCAR meeting.

SCAR also brings together standing committees of specialists with interests in data and information management, in Antarctic geographic information, and in the provision of advice to the Antarctic Treaty system, not forgetting an action group dealing with the history of Antarctic research.

Oversight of SCAR's scientific programme comes from three standing scientific groups, one for physical science, one for the life sciences and one for the geosciences. These in turn report either to the national SCAR delegates, at their biennial meetings, or to the SCAR executive committee, which manages SCAR on behalf of the delegates in the periods between those meetings. The chief officers of the three standing scientific groups meet about once a year with the leaders of the scientific research programmes to encourage interdisciplinary interactions. Actual day-to-day organisation is the responsibility of a small SCAR secretariat, based at the Scott Polar Research Institute in Cambridge.

The key to solving the complex environmental problems of today is through partnerships with organisations having complementary skills, technologies and interests. The implementation of SCAR's programmes depends on the cooperation of the national operators, who are responsible for logistics and who organise themselves into a coherent science support network through the Council of Managers of National Antarctic Programmes (COMNAP), which brings the national operators together annually to examine progress, develop plans, and learn about best practice. SCAR meets with COMNAP annually, and from time to time the two submit joint papers to the Antarctic Treaty Consultative Meeting (ATCM). SCAR is also a partner to several scientific organisations having a global reach and with some regional interest in

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Table 3. The SCAR science groups in spring 2008.

Type	Title
Action group	Sub-ice geological exploration (SIGE)
	Acoustics in the marine environment
	Biological monitoring
	Census of Antarctic marine life (CAML)
	Marine biodiversity information network (MarBIN)
	Continuous plankton recorder (CPR)
	Environmental contamination in Antarctica (ECA)
	Pan-Antarctic observing systems (PantOS)
	King George Island
	Antarctic fuel spills
Expert group	Geodetic infrastructure of Antarctica (GIANT)
	Permafrost and periglacial environments (PPE)
	International bathymetric chart of the Southern Ocean (IBCSO)
	Antarctic digital magnetic anomaly project (ADMAP)
	Higher predators (birds/seals)
	Human biology and medicine
	Antarctic astronomy and astrophysics (AAA)
	Oceanography (OCEANS) [joint with SCOR]
	Operational meteorology (OpMet)
	Ice sheet mass balance and sea level (ISMASS)
	Ice drilling technology (DRILL)
Scientific research programme	Antarctic climate evolution (ACE)
	Subglacial Antarctic lake environments (SALE)
	Antarctica and the global climate system (AGCS)*1
	Inter-hemispheric conjugacy effects in solar–terrestrial and aeronomy research (ICESTAR)
	Evolution and biodiversity in the Antarctic (EBA)

*1 AGCS incorporates two expert groups: the International Trans-Antarctic Scientific Expedition (ITASE), and Antarctic Sea Ice Processes and Climate (ASPeCt).

the Antarctic. For instance, SCAR co-sponsors an oceanography expert group with SCOR, co-sponsors the climate and cryosphere (CliC) programme with the World Climate Research Programme (WCRP), co-sponsors the International Trans-Antarctic Scientific Expedition (ITASE) with the International Geosphere-Biosphere Programme (IGBP), co-sponsors the census of Antarctic marine life (CAML) with the US Sloan Foundation, and also co-sponsors the integrated partnership on ice core sciences (IPICS) and the integrated climate and ecosystem dynamics (ICED) programme. SCAR also partners its Arctic counterpart, the International Arctic Science Committee (IASC), in several areas of bipolar interest, including co-sponsorship of the 2008 open science conference in St Petersburg. And SCAR is a recent partner in the global biodiversity information facility (GBIF). Through these links, SCAR is now developing plans for the observing systems that will ensure the capture of knowledge and understanding of oceanic and cryospheric systems in the Antarctic that we need as the basis for improved forecasts of change. Goodison and others (2007), and Summerhayes and others (2007) describe developments in the bipolar cryosphere observing system and the Southern Ocean observing system, respectively.

SCAR's outputs comprise papers in scientific journals, SCAR reports, and SCAR products and services that may be widely used by national operators and the general public as well as by scientists. Table 4 lists SCAR's products and services. Less tangible, but no less valuable, outputs include the creation of scientific communities with special interests, for instance in topics such as seals, or birds, or astronomy; the awards of fellowships to young researchers; and the awards of medals for science and international cooperation.

Table 4. SCAR's products and services as at spring 2008.

Antarctic data directory system (ADDS)
Reference Antarctic data for environmental research (READER)
Antarctic digital database (ADD)
Antarctic biodiversity database (marine and terrestrial)
Marine biodiversity information network (MarBIN)
Composite gazetteer of Antarctica
Seismic data library system (SDLS)
Geodetic master index for Antarctic positional control
Geodectic control database
Antarctic map catalogue
Antarctic bedrock mapping (BEDMAP)
Tide gauge data
International bathymetric chart of the Southern Ocean (IBCSO)
Antarctic digital magnetic anomaly project (ADMAP) Map
The SCAR King George Island geographical information system (KGIS)
SCAR Feature catalogue
Continuous plankton recorder (CPR) database

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On the education side, apart from the SCAR fellowship programme, SCAR is a partner with the International Polar Foundation and others in the IPY Sixth Continent Initiative, a fellowship programme encouraging young scientists from developing countries to engage in Antarctic research. SCAR is also an associate in the International Antarctic Institute, a collaborative multi-partner international distance-learning organisation that is working towards the development of a comprehensive Antarctic science education programme including a Master's degree. And SCAR supports the activities of the Association of Polar Early Career Scientists (APECS), an organisation that developed as part of the current IPY and will be part of its legacy.

A good example of a major collaborative programme inspired by SCAR was the Biological Investigations of Marine Antarctic Systems and Stocks (BIOMASS) Programme (1977–1991), led by SCAR in a consortium including the Scientific Committee on Oceanic Research (SCOR), the International Association of Biological Oceanography (IABO), and the Food and Agriculture Organisation (FAO) of the United Nations. Ships from 12 countries made a grand total of 31 cruises in austral seasons of 1980–1981 (First International BIOMASS Experiment, FIBEX) and 1983–1984 and 1984–1985 (Second International BIOMASS Experiment, SIBEX). As with all SCAR programmes, the BIOMASS fieldwork and analysis were funded through national programmes. SCAR provided coordination in planning operations and integrating results.

BIOMASS established the role of krill in the Southern Ocean ecosystem (El Sayed 1994). It also led directly to the creation of the Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR), and its adoption of an ecosystem based approach to fisheries management. The various BIOMASS data formed the basis for the CCAMLR database.

As a successor to BIOMASS, in 1990, SCAR's group of specialists on Southern Ocean ecology developed the ecology of the Antarctic sea ice zone (EASIZ) programme to investigate the role of sea ice in the Antarctic coastal marine ecosystem. EASIZ overturned some previous paradigms by establishing that the system is not species poor; it is not relatively undisturbed; it is complex, not simple; and it does not shut down in winter (Arntz and Clarke 2002; Clarke and others 2006).

The modern equivalent of BIOMASS is the Census of Antarctic Marine Life (CAML) which will probably involve some 17 ships, and which had its first cruise in December 2006.

On land, SCAR's RiSCC programme (Regional Sensitivity to Climate Change in Antarctic Terrestrial and Limnetic Ecosystems) has helped to improve understanding of the interactions between climate change and indigenous and introduced species, and the way ecosystems function. Like other SCAR projects, RiSCC brought the community together by generating international expeditions, by creating scientific networks, and by stimulating the formation of groups with particular regional foci (Bergstrom and others 2006).

SCAR scientists have also made major contributions to understanding such diverse phenomena as Antarctic weather, the evolution of Antarctic climate, the mass balance of the Antarctic ice sheet, the development of sea ice, the distributions of seabirds and seals, invasive species, the suitability of Antarctica for an astronomical observatory, an understanding of Sun–Earth interactions in the upper atmosphere, subglacial lake environments, geodesy, magnetism, and the effects of underwater acoustics on whales (SCAR, 2007).

SCAR has also significantly influenced the way the Antarctic Treaty has developed since being signed into law in 1961 (Table 5).

The fourth International Polar Year 2007–2009

The idea of celebrating the 50th anniversary of the IGY and the 125th anniversary of the first IPY arose in 1999 and was discussed at the SCAR meeting in Tokyo in the year 2000 (Bell 2007). At the SCAR meeting in Shanghai in July 2002, Heinz Miller of Germany's Alfred Wegener Institute for Polar and Marine Research presented a plan for IPY science for 2007, calling for a series of multidisciplinary traverses across the divides of East Antarctica in the IDEA project (Ice Divide of Eastern Antarctica). Delegates supported the proposal that there should be an IPY programme to celebrate the 50th anniversary of the IGY and it was suggested that enquiries should be made to ICSU and IUGG. C.G. Rapley agreed to follow up this proposal. Later in 2002 the US National Academy of Sciences held an international workshop to explore the possibility of holding an IPY in 2007, and confirmed its feasibility. In parallel, R. Bell (USA) and C.G. Rapley (UK) presented ICSU with a proposal to form a planning committee for the IPY, which was duly approved.

The fundamental concept of the IPY 2007–2009 was of an intensive burst of internationally coordinated, interdisciplinary, scientific research and observations focused on the Earth's polar regions during an official observing period from 1 March 2007 until 1 March 2009 (ICSU 2004). The IPY would aim to exploit the intellectual resources and science assets of nations worldwide to make major advances in polar knowledge and understanding, while leaving a legacy of new or enhanced observational systems, facilities and infrastructure. Arguably the most important legacies would be a new generation of polar scientists and engineers, as well as an exceptional level of interest and participation from polar residents, schoolchildren, the general public, and decision-makers worldwide. The IPY would strengthen international coordination of research and enhance international collaboration and cooperation in polar regions. Interdisciplinary approaches would be emphasised to address questions and issues lying beyond the scope of individual disciplines.

The timing was thought to be especially appropriate given the rapidly accumulating signs that global warming

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Table 5. Influence of SCAR on development of Antarctic Treaty instruments.

1	Provided advice that led in 1964 to the adoption by the Antarctic Treaty of the Agreed Measures for the Conservation of Flora and Fauna
2	Provided further advice leading in 1991 to the Agreed Measures forming the core of a more comprehensive environmental agreement: the Protocol of Environmental Protection to the Antarctic Treaty
3	Developed the original concepts of Sites of Special Scientific Interest and Specially Protected Areas for Antarctica
4	Provided exemplar framework for management plans for Antarctic Specially Protected Areas (ASPAs) based on Moe Island
5	Provided a management plan handbook and a visit report form, as well as the scientific advice to modify and edit plans for these sites
6	Designed the checklist for environmental inspections under the Antarctic Treaty
7	Together with COMNAP, developed the Environmental Impact Assessment (EIA) Guidelines and good practice
8	Together with COMNAP, developed the Environmental Monitoring Handbooks
9	Organised the workshop with IUCN that put environmental education onto the ATCM agenda
10	Provided key advice that led to the Treaty Parties adopting the IUCN criteria for listing and delisting species
11	Provided the advice that led to the delisting of fur seals
12	Through BIOMASS, provided the foundation for the creation of the Scientific Committee of CCAMLR
13	BIOMASS database was adopted by CCAMLR as the basis for its initial work programme
14	Provided CCAMLR with data on higher predators
15	Heavily involved in initiating and developing the Convention for the Conservation of Antarctic Seals.
16	Published reports containing advice for the negotiation of the Convention on the Regulation of Antarctic Mineral Resource Activities (CRAMRA)
17	Developed codes of conduct for (a) fieldwork, and (b) the use of animals for scientific purposes in Antarctica. This advice is being revised at time of writing (end 2007).

was having its most powerful effect in the polar regions, where there was ample evidence for shrinking sea-ice, melting permafrost, and retreating glaciers.

In June 2003, ICSU formed an IPY planning group to take the process forward. The group held its first meeting in August 2003. It was agreed that the process should be 'bottom-up', driven by ideas emerging from the scientific community (ICSU 2004; Bell 2007). Each interested nation was asked to establish a national committee and begin a national planning process; 32 IPY national committees or points of contact participated. Through discussions, 'town meetings' and two consultative forums, both held in Paris on 31 March and 13–14 September 2004, the group was able to define six scientific themes that provide the fundamental framework for the IPY (Table 6). A key departure from previous IPYs, and the IGY, was the incorporation of biology and chemistry as integral components of the natural sciences, along with inclusion of social sciences to address the human dimension, especially for the Arctic. Another key departure was the development of detailed plans for education and outreach to the wider community, and for data and information management (ICSU 2004).

A framework document outlining the major scientific areas and the process for moving forward was published in October 2004 (ICSU 2004), completing the work of the planning group.

Independently of ICSU, a group at the WMO, which in its former guise as the IMO had sponsored the first and second IPYs, had begun considering development of an IPY. In May 2003, its fourteenth congress approved the concept of an IPY as a means of achieving a broad set of research objectives, among them improvements in the World Weather Watch Global Observing System, establishment of an Arctic Hydrological Cycle Observing System, and the development of Arctic and Southern Ocean Observing Systems. Communication with ICSU was quickly established, and WMO joined the ICSU planning group in an advisory role. In February 2004, the ICSU executive board agreed that WMO should partner ICSU in taking matters forward.

In October 2004, ICSU and WMO formed the ICSU/WMO IPY joint committee (JC) to be responsible for overall scientific planning, coordination, guidance and oversight of the IPY (ICSU/WMO 2007). This steering group has a co-chair from each of ICSU and WMO, and is supported by an international programme office (IPO). SCAR and its Arctic counterpart, IASC, are *ex officio* members of the JC so as to ensure effective linkages to the existing structures for scientific coordination in the polar regions. A consultative forum provides the means for dialogue with the wider IPY community and a vehicle for guiding the JC on IPY development. Following an international competition, the IPO became housed at the British Antarctic Survey in Cambridge, and an executive director (D. Carlson) was employed. In accordance with the plan, two subcommittees were established, one on education, outreach and communication (EOC), and one on data policy and management (DPM). From the start it was agreed that to ensure free and open data exchange, all endorsed IPY projects and their participants must agree to an IPY data and information management policy and submit project information (metadata) and data to an agreed timetable. With these developments the IPY

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Table 6. The IPY themes:

1.	Status: to determine the present environmental status of the polar regions;
2.	Change: to quantify and understand past and present natural environmental and social change in the polar regions and to improve projections of future change;
3.	Global linkages: to advance understanding on all scales of the links and interactions between polar regions and the rest of the globe, and of the controlling processes;
4.	New frontiers: to investigate the frontiers of science in the polar regions;
5.	Vantage point: to use the unique vantage point of the polar regions to develop and enhance observatories from the interior of the Earth to the Sun and the cosmos beyond;
6.	The human dimension: to investigate the cultural, historical and social processes that shape the sustainability of circumpolar human societies and to identify their unique contributions to global cultural diversity and citizenship.

moved from the design phase to the implementation phase.

The joint committee, chaired by I. Allison and M. Beland, held its first meeting from 7–9 March 2005, in Paris. Subsequent additions to the management structure included an IPY international programme sub-office in St. Petersburg, and an observations subcommittee, within which a space task force provides focus on plans for satellite remote sensing. As noted above young scientists have formed an Association for Polar Early Career Scientists (APECS), and coordination with national IPY committees is improved through meetings of the heads of Arctic and Antarctic IPY secretariats.

During 2004, on the advice of the planning group, ICSU and WMO asked scientists to submit proposals for scientific activity in the form of an 'expression of intent' (EoI). In due course, over 1000 EoIs were submitted. They form the foundation of the science framework for the IPY (ICSU/WMO 2007). The JC clustered these proposals into coherent groups, identified likely lead groups for each cluster, and invited the proposers to combine their efforts into a smaller set of comprehensive and integrated full proposals. By early 2006, some 228 of these comprehensive project proposals had been endorsed by the committee (ICSU/WMO 2007). They show that the IPY will involve some 50,000 people from 63 countries, and so will be about the same scale as the IGY. 57 of the projects are in education and outreach, featuring new films, exhibits, books and atlases; university courses and educational materials; and projects involving youth and polar communities. By mid 2007 it was clear that the majority of the endorsed projects would be funded completely or in part. At least US$500 million over and above normal polar research allocations will be injected into polar research.

An overview of the exciting new science in the IPY and the expected outcomes is given in the scope of science document published in February 2007 (ICSU/WMO 2007). Progress can be reviewed on the IPY web site at www.ipy.org. Not only are most endorsed IPY projects strongly collaborative internationally as well as interdisciplinary, they also are cross-thematic, most being targeted at more than one of the IPY science themes. The international nature of the individual projects, and their common interdisciplinary nature, is a further departure from the nature of the IGY and previous IPYs, in which the focus was on single discipline science projects mainly effected by single nations. This broad international effort should contribute to a future of increased cooperation between scientists, organisations and nations in the knowledge and rational use of our planet.

The IPY will also contribute to understanding the contribution of science from the remote polar regions to the global topic of 'sustainable development'. The polar regions may be far away from where most development occurs, but these icy regions are integral components of the global system and what happens there affects what happens elsewhere: the most notable example being where melting ice raises global sea level. Rising seas will threaten coastal development everywhere.

In due course, the fourth IPY will leave behind a legacy that should enable more science to be undertaken yet more efficiently and effectively in the polar regions. That legacy is sure to include improved systems for observing status and change as the basis for improved forecasts of likely further change. Together with the IPY-JC, SCAR and its northern counterpart, IASC, are now actively considering what that legacy is likely to comprise and how best to organise the community to manage it. There seems little doubt that if a SCAR did not already exist it would have to be invented to take on key aspects of this challenge.

Three major international conferences will review progress with the IPY. Early results will be reviewed at the SCAR/IASC IPY open science conference in St Petersburg, Russia, from 8–11 July 2008. Progress at the end of the IPY will be addressed at a conference in Oslo, Norway, from 8–10 June 2010. And there will be an IPY science and policy conference probably in Canada in 2012, to review the implications of science for policy makers.

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