Conclusions

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GOVERNING ANTARCTICA

Throughout human history, nations and empires have colonized territories across the Earth and claimed jurisdiction over these areas, resulting too often in conflicts. To end the battles and wars, protagonists have signed treaties, such as the Treaty of Westphalia in 1648, which solidified the concept of the nation-state, blending cultural and political authority within geographic boundaries. Curiously, just a few years before, in 1609, the Dutch jurist Hugo Grotius published *Mare Liberum*, a treatise articulating freedoms of the sea existing beyond the jurisdiction of nations (Bull et al., 1990). Together, these legal paradigms developed in the seventeenth century reveal a global governance dichotomy that is with us still and that features national spaces governed by states acting on the basis of national interests juxtaposed to international spaces in which all nations have common interests.

Three centuries later, Antarctica was no different than other areas on Earth where nation-states assert their sovereign jurisdiction (Lüdecke, this volume). Like a pie, the division of Antarctica started with the letters patent from the United Kingdom in 1907 and continued with additional claims by New Zealand, France, Australia, Norway, Argentina, and Chile by 1943. With the aide-memoire and draft agreement that the United States transmitted in secret to the seven claimant nations in 1948, Antarctica was positioned to become just another domino in the history of territorial expansion.

This nation-state trajectory in Antarctica shifted course dramatically with the emergence of the vision underlying a Third International Polar Year (renamed the International Geophysical Year) and the statesmanship of President Eisenhower of the United States in the early 1950s (Berkman, this volume). The International Geophysical Year (IGY) of 1957–1958 provided a coordinated international avenue for synoptic studies of the Earth as an interconnected geophysical system combining land, air, and water with forcing from the Sun. This was followed by the International Biological Program (1964–1974), an attempt to apply the big science approach to ecosystem functioning and productivity at a global scale (Worthington, 1975). Biological dynamics of the Earth as an interconnected system, as illustrated by the Gaia hypothesis (Lovelock and Margulis, 1974), would be investigated subsequently on a planetary scale with the inception during the 1980s of the International Geosphere-Biosphere Programme and the growth of Earth system science. It was satellites with their unmistakable rocket relationship to ballistic missiles, however, that became the national security item that most engaged the superpowers during the IGY in the 1950s.

Ultimately, the IGY paved a diplomatic path, underlain by science, to establish the region south of 60°S, encompassing nearly 10% of the Earth's surface, as an international space where all claims to territorial sovereignty would be held in abeyance (Jacobsson, this volume).[1] Adopted on 1 December 1959 in Washington, D.C., the Antarctic Treaty articulates the premise that

> establishment of a firm foundation for the continuation and development of such cooperation on the basis of freedom of scientific investigation in Antarctica as applied during the International Geophysical Year accords with the interests of science and the progress of all mankind.

The two world wars of the twentieth century underscored animosity on a global scale. In contrast, reflecting unparalleled international cooperation, institutions have evolved since 1945 to prevent or resolve disputes transcending national boundaries. Most of these institutions relate to issues that cross national boundaries. However, there is a suite of institutions that has emerged to manage regions beyond the reach of national jurisdiction in the high seas (1958), Antarctica (1959), outer space (1967), and the deep sea (1971). On Earth, these international spaces extend across nearly 70% of our planet's surface (Young, this volume). The Antarctic Treaty reflects a new vision of an interconnected global society starting with Antarctica "forever to be used exclusively for peaceful purposes."

The Antarctic Treaty was crafted by the seven claimant nations along with five nonclaimant nations (Belgium, Japan, the Republic of South Africa, the Union of Soviet Socialist Republics, and the United States of America). As of August 2010, there are 47 signatories to the Antarctic Treaty (Retamales and Rogan-Finnemore, this volume), including Monaco as the most recent Acceding Party (Albert II, this volume). The origin, development, and implications of the Antarctic Treaty are intimately associated with science, revealing lessons that offer hope and inspiration.

For the benefit of present and future generations—the global challenge is to balance national interests and common interests. Science diplomacy is the international, interdisciplinary and inclusive process to achieve this global balance for the benefit of all life on Earth.

SCIENCE DIPLOMACY LESSONS FROM ANTARCTICA

The origin, administration, and development of the Antarctic Treaty are intimately associated with the conduct of science. The lessons we draw from the Antarctic experience regarding science diplomacy will be of lasting and global significance. The opportunity here is to understand these science diplomacy lessons and to identify their implications for meeting governance needs at the international level. In this section, we identify a number of major lessons emerging from the Antarctic experience. The following subsections explore these lessons with relevance beyond the confines of Antarctica.

Science as an Instrument for Earth System Monitoring and Assessment

Recognizing that science extends across a continuum from basic to applied research (Berkman, 2002), science diplomacy is strongly influenced by discoveries and insights that have practical benefits for society. Such applied research is commonly seen in terms of monitoring and assessing human impacts on natural systems.

In the Antarctic Treaty System (ATS), environmental impact assessment is integrated into the 1991 Protocol on Environmental Protection to the Antarctic Treaty (Madrid Protocol), which introduces the concept of a "minor or transitory impact" (Orheim et al., this volume). On one hand, "minor" involves subjective elements associated with values that have been articulated in diverse ATS measures,[2] including the "value for global baseline monitoring," "unique ecological and scientific value," "value of increasing public knowledge," "value of cooperation," and the "outstanding geological, glaciological, geomorphological, aesthetic, scenic, or wilderness value."

On the other hand, transitory involves objective elements associated with rate-related processes defined in the ATS, such as "changes in the marine ecosystem which are not potentially reversible over two or three decades" (Miller, this volume), as articulated in Article II of the 1980 Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR). As a whole, the concept of a "minor or transitory impact" is a microcosm of the science-policy coupling that has been evolving in the ATS throughout its first 50 years, bringing together both subjective and objective elements that are necessary for good decision making.

SCIENCE AS THE ESSENTIAL GAUGE OF CHANGES OVER TIME AND SPACE

Science is a process of discovery based on a method of hypothesis testing to assess the dynamics of systems: natural and social, small and large, young and old. At the heart of this process is investigation of changes over time and space (Thiede, this volume). Science provides a framework to look backward and forward in time to characterize rates and durations of phenomena as well as their feedbacks. Science places events in context, such as regional weather patterns operating within our global climate system. Importantly, for the benefit of our global society, science reveals interactions between natural and anthropogenic processes at multiple scales.

Time and space are blurred over cosmological dimensions back to the origin of the universe. “The farthest we can see is 13.7 billion light years distant, to a time that was only 350,000 years after the big bang” (Stark, this volume).

Climate, which is a planetary process that has oscillated regularly between glacial cold and interglacial warm periods for the last few million years with principal forcing from the Sun, illustrates temporal and spatial variability in the Earth system (Petit, this volume). The “sawtooth” pattern of climate changes, seen from high-resolution ice cores in the East Antarctic Ice Sheet and Greenland Ice Sheet, reveals that the current warm period is anomalously long compared to previous interglacial periods during the past 800,000 years. The ice core records also demonstrate that carbon dioxide concentrations and temperatures in the atmosphere have been increasing since the beginning of the industrial era (circa 1850) to current levels that are well above any seen in the Earth system over the past eight climate cycles. The inferred atmospheric variability also mimics sea level changes that have been deduced from marine sediments. Such proxy records demonstrate variations in the Earth system over years and decades embedded within centuries and millennia.

These long-term proxies are complemented by real-time measurements that have been made by various types of instruments, producing records of modern events and phenomena as they are happening. In Antarctica, there is a continuous daily weather record at Orcadas Station going back to the Scottish National Antarctic Expedition in 1903 (Zazulie et al., 2010). Starting in 1958 during the IGY, continuous atmospheric carbon dioxide measurements have been made at the South Pole (as well as at Mauna Loa in Hawaii), showing seasonality and increasing global concentrations of this greenhouse gas (Scripps CO_2 Program, 2010). Such real-time measurements reveal changes in the Earth system over days and seasons embedded within years and decades.

Together, the proxy and real-time records provide the context to understand events (e.g., a once in a century flood or warmest decade in the last millennium) that impact humankind. Science contributes to fundamental understanding about the magnitudes, rates, and dynamics of Earth system phenomena that must underpin any adaptation and mitigation policies. The challenge is to design and implement the appropriate strategies over time spans that far exceed the electoral cycles of the decision makers.

SCIENCE AS A SOURCE OF INVENTION AND COMMERCIAL ENTERPRISE

Although scientific activities may be initiated with national funding for basic research purposes, discoveries also can reveal opportunities for potential or actual commercial gain. A living resource example from the Antarctic, as from other regions beyond national jurisdictions, is the potential exploitation of genetic resources from unique species that can be amplified, patented and marketed (Berkman, 2010a). This biological cousin to the exploitation of geological deposits constitutes an emerging challenge known as bioprospecting (Joyner, this volume).

The more well-known challenge focuses on mineral resources, as illustrated by scientific results of the *Glomar Challenger* expedition from the Deep Sea Drilling Program in the early 1970s (Walton, this volume), which were suddenly and wildly interpreted in the *Wall Street Journal* as offering the prospect of hundreds of millions of barrels of oil and trillions of cubic feet of natural gas on the Antarctic continental shelf. The mineral resource potential of Antarctica awakened intense international interest, opened the door for questions to be addressed in the United Nations, and led to the development of the Convention on the Regulation of Antarctic Mineral Resource Activities, a legal instrument that has never entered into force (Scully, this volume). Subsequently, the Madrid Protocol prohibited any activity relating to mineral resources, other than scientific research (Golitsyn, this volume).

In addition to identifying potential resources, science plays a role in developing the technologies needed to exploit these resources. However, there is a key difference between commercial and scientific activities, which is demonstrated by the issue of access to information.

Commercial activities restrict information access. To avoid this trajectory, with leadership of the Scientific Committee on Antarctic Research (SCAR), for marine geological resources, at least, the Antarctic Offshore Stratigraphy project (ANTOSTRAT) has been working since the late 1980s to share seismic data that companies otherwise would hold as proprietary (Cooper et al., this volume). Thus, scientific activities facilitate information access and transparency in such a way as to extend cooperation and prevent conflict.

Science as an Early Warning System

Scientific research often yields insights about impending abrupt and irreversible changes in the dynamics of natural systems (Erb, this volume). The pace of global changes seems often to be more rapid in the polar regions than elsewhere in the Earth system (Holland and Bitz, 2003).

Measurements of the changes in the mass balance of the Antarctic ice sheets will provide an early warning of the impacts of sea level rise (Kennicutt, this volume), a global change that will affect the stability of nation-states and the lives of billions of people. Such early warning will also be important to understand the changing flows of Antarctic Bottom Water and North Atlantic Deep Water, which are important drivers of the circulation and biogeochemical cycling of the ocean as well as the global inventory of carbon dioxide (Rintoul, this volume), which impact marine and terrestrial ecosystems across the Earth.

Data on atmospheric ozone depletion, which allows higher concentrations of ultraviolet radiation from the Sun to reach the Earth's surface, have served as a particularly urgent early warning (Solomon and Chanin, this volume). Because of genetic damage, most notably in the form of skin cancers that would ensue worldwide, the 1985 Convention for Protection of the Ozone Layer (Vienna Convention) and its 1987 Protocol on Substances that Deplete the Ozone Layer (Montreal Protocol) were quickly adopted in response to this global threat (Sarma and Anderson, this volume). The ozone story at once reveals unequivocal anthropogenic impacts to the Earth system on a global scale, while highlighting the central roles and responsibilities of the international scientific community in providing early warnings about impending threats that can be translated into adaptation or mitigation policies.

Uncontrolled fishing in the Southern Ocean in the early 1970s alerted the SCAR marine community to a potential ecological disaster of the type that had occurred elsewhere in the world (Walton, this volume). Rapid action to investigate these Antarctic fishery impacts provided the basis for international agreement and regulation through CCAMLR.

Science as a Determinant of Public Policy Agendas

Antarctica and its surrounding seas drive much of the Southern Hemisphere weather systems, form bottom waters that propel the global ocean conveyor (Broecker, 1991), absorb a major component of atmospheric carbon, reflect much of the solar radiation that enters the Earth system, and contribute significantly to global sea level. All of these natural phenomena are of major importance, not just for the Antarctic Treaty nations, but for life on Earth.

Antarctic science has become topical, essential, and strategic. It may be expensive, but evidence from the last 50 years is that we need more not less research there if we are to predict the future state of the world accurately enough to plan for our survival. Fortunately, the ATS has become increasingly aware of its responsibilities for Antarctic diplomacy and science, providing an important foundation for international and interdisciplinary research that reveals the dynamics of the Earth system with direct relevance to humankind.

Scientific advances often give rise to policy issues where they did not exist before, especially in relation to natural phenomena and technological innovations. In some cases, the policy process itself exposes solutions or challenges that can be generalized. Two science-policy examples from Antarctica involve ecosystems and climate.

In 1976, a SCAR Group of Specialists was formed on Biological Investigations of Marine Antarctic Systems and Stocks (BIOMASS) to assess keystone relationships of krill (*Euphausia superba*) to other species in the Southern Ocean south of the Antarctic Convergence (El-Sayed, 1994). This assessment led to a recognition that a species-by-species approach was insufficient to manage harvesting impacts effectively in the Antarctic marine ecosystem. In contrast to the 1972 Convention on the Conservation of Antarctic Seals, it was necessary to consider the interactions of species with their habitats across trophic levels from the phytoplankton to the krill and bird, fish, seal, squid, and whale predators. Embodied in Article II of CCAMLR, this ecosystem approach called for maintaining the "ecological relationships between harvested, dependent and related populations" (Miller, this volume). The underlying concept of interdependence was further elaborated in the 1991 Madrid Protocol to "enhance the protection of the Antarctic environment and dependent and associated ecosystems."

Policy measures emphasizing the term "ecosystem" were adopted for Antarctic protected areas in 1964, well before other regions around the world, as reflected by the Digital Library of International Environmental and Ecosystem

Policy Documents that spans the period from 1818 to 1999 (Marine Mammal Commission, 2007). Today, ecosystem-based management is a widely accepted approach applied to address human impacts in marine systems around the world (Levin and Lubchenco, 2008) as well as to issues involving freshwater and terrestrial systems.

Since World War II, international environmental and ecosystem agreements have grown at an exponential rate (Berkman, this volume), with connections to scientific discoveries that are unmistakable. These discrete solutions dealing with all manner of Earth system phenomena have expanded into an integrated fabric of policies on a planetary scale, as represented by climate. This policy trajectory also is mirrored in the Antarctic, where the value of the environment for global baseline monitoring was recognized in the 1960s, two decades before climate research was incorporated into the policy measures. These global science-policy developments are coupled with technological advances, most profoundly involving data collected by satellites that yield perspectives of the Earth system and its dynamics.

Climate, like science diplomacy, is merely a term for a process that has long been understood. In 1882–1883, for example, 12 European nations convened the first International Polar Year (IPY) with a national security focus on glacial weather conditions that had impacted their agriculture and economies for the preceding four centuries during the Little Ice Age (Berkman, 2003). During the nineteenth century, science already was tasked with contributing to international policies that relate to climate as we define it today and for the same reasons.

Science as an Element of International Institutions

Science contributes fundamentally to the implementation of sustainable development strategies that seek to balance environmental protection, economic prosperity, and social justice into the future. When regions or resources, natural phenomena, or technologies are the policy focus, science is built into the institution. At the international level, the Antarctic Treaty is a seminal illustration of scientific contributions to institutional design and implementation (Jacobsson, this volume).

Starting with the Preamble, which articulates the vision that “Antarctica shall continue forever to be used exclusively for peaceful purposes and shall not become the scene or object of international discord,” the contributions of science are incorporated into the major elements of the Antarctic Treaty. To construct this firm foundation, science is elaborated in Articles I, II and III with regard to peaceful purposes, scientific investigation, and international cooperation, respectively. Together, these three articles emphasize the freedom of scientific investigation along with the open exchange of scientific observations, results, personnel, and program plans. To further facilitate information exchange and provide for essential continuity between meetings, an important recent addition to the ATS has been its secretariat (Huber, this volume).

In addition, to ensure competent advice, cooperation is established with “international organizations having a scientific or technical interest in Antarctica” (Cohen, this volume). As recommended at the First Antarctic Treaty Consultative Meeting (ATCM) in 1961, the first scientific organization to be recognized was SCAR (Walton, this volume), whose “most valuable contribution” preceded the Antarctic Treaty.

This marriage between science and policy in the Antarctic Treaty generated the 1972 Convention on the Conservation of Antarctic Seals with its policy-making arm and key contributions from SCAR to “achieve the objectives of protection, scientific study and rational use of Antarctic seals, and to maintain a satisfactory balance within the ecological system.” The science-policy architecture of the Antarctic Treaty also was transferred into CCAMLR, which has a commission with a Scientific Committee and a secretariat to achieve its objectives (Scully, this volume).

In all, the Antarctic Treaty uses the terms science, scientific, or research in the Antarctic Treaty 18 times. The central importance of science is integrated into Article IX, which refers to consultation on matters of common interest. Facilitation of scientific research and international scientific cooperation are two of the six common interests. Importantly, as opposed to any political, economic, or cultural criterion, Article IX establishes “substantial research activity” as the standard a state must meet to become an Antarctic Treaty Consultative Party (ATCP), giving rise to a two-tiered system that also includes signatories that have acceded to the Antarctic Treaty without becoming Consultative Parties (Triggs, this volume).

In practice, the complex and expensive logistics needed to conduct scientific research in Antarctica require ongoing support from national programs. Since 1988, with the involvement of the 28 ATCPs, the Council of Managers of National Antarctic Programs (COMNAP) has provided a regular forum to coordinate the ships, helicopters, planes, and research facilities for delivery of the science that is fundamental to the success of the ATS (Retamales and Rogan-Finnemore, this volume).

At once, the Antarctic Treaty demonstrated how science can imbue an international institution with the resilience needed to establish a policy-making system that can evolve and respond effectively to ever-changing circumstances (Scully, this volume; Wolfrum, this volume). This is not to say that the ATS is without a need for improvement, as noted in several contributions to this volume (Huber, this volume; Barnes, this volume). Moreover, there are growing concerns, as with the case of tourism (Landau, this volume), about the need for the ATS to improve its oversight to ensure human safety and environmental protection in the region south of 60°S latitude. Nonetheless, the demonstration is clear and compelling that the ATS has become a model of international cooperation to resolve varied and complicated issues over the past half century, largely because science has a been a key element of its design and implementation.

Science as a Tool of Diplomacy

The Antarctic Treaty emerged during the height of the cold war, creating a firm foundation that promotes cooperation and prevents conflict among adversaries and allies alike "on the basis of freedom of scientific investigation." Although the scientific roots of this international collaboration in Antarctica are deep, extending back to the nineteenth century (Roots, this volume), the imperative came from the terrible losses encountered by all humankind when our world was urgently seeking strategies to build trust, identify common interests, and promote lasting peace among nations. This global imperative is no less critical today, and there is no room for complacency in learning and applying the lessons from our past.

Following the devastation of World War II, which President Eisenhower understood firsthand as a supreme Allied commander, it was vital to promote cooperation and prevent such conflict from ever happening again on a global scale, especially with the development of ballistic missiles capable of carrying nuclear weapons over intercontinental distances (Berkman, this volume). Yet the United States and Soviet Union, the two superpowers with nuclear capacities, were locked in cold war brinksmanship without the ability to negotiate on issues involving ballistic missiles, as demonstrated by the unequivocal rejection of the Open Skies proposal in 1955.

It was providential that the IGY was being planned for 1 July 1957 through 31 December 1958, with the anticipated initial launch of Earth-orbiting scientific satellites suggesting a need for rules involving freedom of space much like the freedom of the sea. Even though they were launched for peaceful purposes, scientific satellites were unmistakably related to the rockets that would become ballistic missiles. Satellites also were the national security concern that had attracted the Soviet Union to participate in the IGY, opening an avenue of cooperation for the two superpowers to collaborate with other nations in shared international investigation of the Earth system. The timing of the first satellite launch, accomplished with Sputnik during the IGY on 4 October 1957, was the historic consequence of science diplomacy with contributions from influential scientists like Lloyd Berkner (Needell, 2000).

With science as a tool of diplomacy, the IGY inspired international cooperation that enabled the United States and Soviet Union to take the lead in establishing the Antarctic Treaty as the first nuclear arms agreement, despite their inability to negotiate on this issue elsewhere. The Antarctic Treaty similarly stimulated peaceful collaboration between the United States and Japan on an equal footing when such interactions were barely imaginable so soon after World War II (Yoshida, this volume).

With the precedent of the 1959 Antarctic Treaty, the 1967 Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies (Outer Space Treaty) became the next legal regime to prohibit the emplacement of nuclear weapons in an international space that had never been armed (Kerrest, this volume). The third demilitarization regime was the 1971 Treaty on the Prohibition of the Emplacement of Nuclear Weapons and Other Weapons of Mass Destruction on the Sea-bed and the Ocean Floor and in the Subsoil Thereof (Deep Sea Treaty). Together, these three regimes along with the 1958 Convention on the High Seas (since incorporated into the 1982 United Nations Convention on the Law of the Sea) established four international spaces that humankind has elected to manage beyond the reach of national jurisdiction.

The nuclear issue arose also in connection with the "Question of Antarctica" that India placed on the United Nation agenda in 1956 "to affirm that the area will be utilised entirely for peaceful purposes and for the general welfare" (Jacobsson, this volume). The scientific focus of the Antarctica Treaty subsequently encouraged India to conduct "substantial research activity" and to become an ATCP itself in 1983. That same year, Malaysia along with Antigua and Barbuda raised the Question of Antarctica again in the United Nations, this time due to an interest in mineral resources (Scully, this volume). The engaging contribution of science as a trust-building tool of diplomacy will be further highlighted when Malaysia accedes to the Antarctic Treaty.

Science also creates functional links among disparate institutions, even when their only formal connections are the policy issues they have in common. For example, the issue of iron fertilization in the sea, as a strategy intended to mitigate greenhouse warming by stimulating phytoplankton production that would sequester atmospheric carbon dioxide, illustrates the institutional interplay between the 1991 Madrid Protocol and other international agreements that relate to marine pollution (VanderZwaag, this volume).

Comparisons between the provisions of the Antarctic Treaty and the Outer Space Treaty illustrate conceptual interplay among institutions relating to international spaces (Race, this volume). Regimes created to govern international spaces that can be neither occupied nor appropriated by nations, where science has fundamental roles and responsibilities to promote cooperation as well as provide advice for policy making and implementation, further reveal an emerging alphabet of common interests for the benefit of our civilization (Wolfrum, this volume)

Over time, additional international agreements have arisen to deal with issues beyond the jurisdiction of nation–states, with transboundary issues that also transcend sovereign jurisdictions. The 1992 United Nations Framework Convention on Climate Change, for example, acknowledges that "change in the Earth's climate and its adverse effects are a common concern of humankind." Similarly, the 1992 Convention on Biological Diversity, affirms that "conservation of biological diversity is a common concern of humankind." In view of functional relationships across the boundaries of nations, the 2003 World Summit on the Information Society has determined that "knowledge is the common wealth of humanity" (Electronic Geophysical Year, 2007)

In general, the unique international value of science is reflected by its principles (Elzinga, this volume). The scientific process is open, producing results that are shared and transparent, promoting cooperation, and preventing conflict. It is telling that the 2007 Nobel Prize to the Intergovernmental Panel for Climate Change was awarded not for chemistry or physics, but for peace. As a lingua franca free of political, cultural, and economic agendas, science fosters international, interdisciplinary, and inclusive dialogues that are crucial to protect our common welfare and the world we live in.

GLOBAL SIGNIFICANCE OF THE ANTARCTIC EXPERIENCE

It is a natural step, then, to ask whether the experience in science diplomacy in Antarctica also holds lessons for those concerned with governance in international society in general terms and more specifically with the governance of global commons. Any lessons we are able to glean from the Antarctic experience will be relevant not only to those interested in traditional international spaces but also to those in search of effective approaches to governing an expanding range of issues (e.g., climate change) that have become matters of intense concern at the global level in recent years and that are destined to become even more important in the future.

In this section, we draw attention to several facets of the Antarctic experience that highlight strategies and precedents for the governance of other international spaces. We also explore similarities and differences between the Antarctic and the Arctic with regard to the needs for governance arising in the polar regions and the role of science in fulfilling these needs.

Governing International Spaces

International spaces are commons in the sense that they are not subject to the rights and rules that we associate with systems of public property, much less systems of private property (Ostrom et al., 2002). At least since the publication of Garrett Hardin's well-known article on the "tragedy of the commons," many have come to regard situations of the sort prevailing in Antarctica and other commons as a recipe for disaster with regard to the management of human-environment relations and to the achievement of effective governance more generally (Hardin, 1968). But no such tragedy has occurred in the case of Antarctica. Although there is no shortage of issues that generate needs for governance in the south polar region, Antarctica is well governed by a system that has demonstrated a considerable capacity to grow and adapt to changing circumstances over a long period of time. How is this possible? What are the implications of this success for efforts to govern other international spaces?

Success in situations of this kind requires both the establishment of structures of rights and rules that serve the interests of the major players in the relevant systems and the development of decision-making procedures capable of adjusting and adapting these arrangements to address changing circumstances. In the case of the ATS, this has meant, first and foremost, accommodating the interests of major claimant and nonclaimant states and setting up the ATCMs as a venue for collective decision making about matters of common interest. But there is more to this story that will be of interest to those concerned with the governance of other international spaces.

The negotiations that culminated in the signing of the Antarctic Treaty on 1 December 1959 profited from both the knowledge and the relationships of trust emerging from the 1957–1958 IGY experience. The criterion for consultative party status in the resultant regime is framed in terms of the level of scientific effort. The governance system that has evolved from this point of departure recognizes the role of the science community operating through SCAR and accords considerable prominence to the work of scientists in prioritizing and framing issues for consideration at the ATCMs and in providing the information needed on a regular basis to assess the results of decisions taken by the ATCMs.

The science community has emerged also as an essential player in the implementation and administration of the ATS. The occupants of the research stations in Antarctica constitute the only human residents of this international space. The provisions of the Antarctic Treaty relating to freedom of movement for scientists and to the conduct of inspections of the activities taking place at individual research stations ensure a high level of transparency with regard to human activities in the region. There is little chance that any substantial violation of the rules governing human activities in the region could escape the attention of members of the science community. Because this community is well known for its international character and for its tendency to avoid becoming enmeshed in the pursuit of national interests, these arrangements have operated to produce both a high level of assurance among the members of the regime regarding compliance with the major provisions of the ATS and considerable confidence regarding the absence of unregulated interventions on the part of nonmembers.

Although no two international spaces are alike, much of the Antarctic experience seems relevant to other international spaces. The high seas, the deep seabed, and outer space are all affected by a variety of human actions. But, like Antarctica, they do not have long-term resident populations that form the basis for powerful interest groups.

Particularly striking in this context is the role that science can play with regard to the implementation and administration of governance systems for international spaces or, in other words, what we now think of as science for diplomacy. Because scientists tend to see themselves as operating in a domain that has little to do with policy making or governance, this role may seem alien to many members of the science community. Yet whether we are thinking of the deep seabed or outer space, scientists are key players in the human activities taking place in or associated with these systems. As in the case of Antarctica, decisions about human uses of these spaces will apply in many instances to the activities of scientists, and scientists will often find themselves in a good position to monitor the extent to which parties comply with the rights and rules of the relevant governance systems. Some may worry that this policy-relevant role of science will have the effect of distracting scientists from their main role as producers of knowledge. But as the concept of Pasteur's Quadrant makes clear, the idea that science has a role to play in addressing matters of public policy is hardly a new one (Stokes, 1997). It is destined to grow in importance during the foreseeable future.

Governing the Arctic

The assumption that there are important similarities between Antarctica and the Arctic with regard to issues of governance is a persistent one (Cava et al., this volume). Yet, as Table 1 makes clear, the dissimilarities between the two polar regions are profound. Aside from the presence of a cold climate and the importance of ice, the antipodes differ from one another in most respects. In terms of our discussion of lessons to be derived from the experience of the ATS, it is critical to note that most of the Arctic (all except an area in the central portion of the Arctic Ocean) does not constitute an international space. The coastal states have jurisdiction not only over all the lands located north of 60°N but also over the waters of their exclusive economic zones (EEZ) stretching seaward from their coasts. The Commission on the Limits of the Continental Shelf is currently addressing issues relating to coastal state jurisdiction over the seabed extending beyond the EEZs in the Arctic Ocean.

Yet the thought that there are lessons to be learned from experiences in each polar region that are relevant to the other will not go away. Despite the dramatic differences between the two regions, there are still insights to be gained from comparing and contrasting Antarctica and the Arctic, with particular reference to science diplomacy. The key to this puzzle lies in the character of the science-policy interface in the two polar regions.

Scientific cooperation in the Arctic and Antarctica has a long history that includes the first IPY in 1882–1883 and runs through the IGY in 1957–1958, the fourth IPY in 2007–2008, and the current effort to extend this collaborative effort by launching an International Polar Decade. Just as SCAR predates the signing of the Antarctic Treaty in 1959, the International Arctic Science Committee (IASC) preceded the creation of the Arctic Environmental Protection Strategy in 1991 and the Arctic Council in 1996. The IASC, much like SCAR, has become an

TABLE 1. Comparison of Arctic and Antarctic characteristics. Adapted from Berkman (2010b).

Characteristic	Arctic	Antarctic
Location	The high-latitude region surrounding the North Pole (90°N latitude)	The high-latitude region surrounding the South Pole (90°S latitude)
Geography	Ocean surrounded by continents	Continent surrounded by ocean
Ecosystems	Strongly influenced by solar cycle poleward of Arctic Circle (66.5°N)	Strongly influenced by solar cycle poleward of Antarctic Circle (66.5°S)
Sea ice	Year-round, mostly multiyear	Seasonal, mostly annual
Continental shelf	Broadest, shallowest on Earth	Narrowest, deepest on Earth[a]
Humans	Indigenous people over millennia	No indigenous people
Science	International Arctic Science Committee	Scientific Committee on Antarctic Research
Territories	Recognized sovereign jurisdictions	Claims to sovereignty[a]
Access	Restricted	Unrestricted
Living resources	Ongoing exploitation	Ongoing exploitation
Mineral resources	Ongoing exploitation	Exploitation prohibited
Ecotourism	Extensive	Extensive
Military presence	Extensive since World War II	Nonmilitarized region
Nuclear weapons	Extensive since World War II	Nuclear-free zone
Common interests	Sustainable development and environmental protection[b]	(1) peaceful purposes only; (2) facilitation of scientific research; (3) facilitation of international scientific cooperation; (4) facilitation of the exercise of the rights of inspection; (5) questions relating to the exercise of jurisdiction; (6) preservation and conservation of living resources[c]
Legal framework	Law of the Sea[d]	1959 Antarctic Treaty[e]

[a] Described and mapped in Berkman (2002).

[b] Defined as "common arctic issues" in the 1996 Ottawa Declaration on the Establishment of the Arctic Council (http://www.international.gc.ca/polar-polaire/ottdec-decott.aspx?lang=en).

[c] Defined as "matters of common interest" in the 1959 Antarctic Treaty, Article IX, paragraph 1 (http://www.ats.aq/documents/ats/treaty_original.pdf).

[d] As expressed in the 2008 Ilulissat Declaration, the five Arctic coastal states "remain committed" to the law of the sea (http://www.oceanlaw.org/downloads/arctic/Ilulissat_Declaration.pdf). The Arctic states all have adopted the 1982 United Nations Convention on the Law of the Sea (UNCLOS Searchable Database, http://lawofthesea.tierit.com), with the exception of the United States.

[e] Antarctic Treaty Searchable Database (http://aspire.tierit.com).

influential source of scientific knowledge underpinning the work of the Arctic Council. Both SCAR and IASC are affiliated with the International Council of Science (ICSU).[3] A sizable proportion of those engaged in polar research are active in both Antarctic research and Arctic research, and SCAR and IASC have begun to collaborate in organizing jointly sponsored scientific meetings and in developing research agendas that make it possible to compare and contrast findings from the antipodes in a rigorous manner.

In the process, activities centered on the polar regions have come to play a prominent role in the development of new perspectives on the science-policy interface. Sometimes discussed in terms of the idea of the coproduction of knowledge, these new perspectives highlight a much more collaborative effort encompassing active cooperation in framing research questions and in setting research priorities as well as in delivering the results of scientific research to policy makers who have played a significant role in guiding scientific research from the outset (Jasanoff, 2004). In both regions, an important result of this collaborative process has been the conduct of what we now know as scientific assessments and the infusion of the results of these assessments into the policy process (Mitchell et al., 2006).

The practices that have evolved in the two regions differ in some significant ways. In the Antarctic case, what are known as SCAR groups of specialists have emerged as central mechanisms in carrying out scientific assessments. In the Arctic, in contrast, the Arctic Council's working groups, operating often in collaboration with IASC, have taken the lead in the preparation of policy-relevant scientific assessments. But as the delivery of the Arctic Climate Impact Assessment (ACIA) to the Arctic Council ministerial meeting in 2004 and the submission of its Antarctic counterpart, the report on Antarctic Climate Change and the Environment (ACCE), to the ATCM in 2009 make clear, this emerging relationship between the science community and the policy community is a progressive step in the creation of effective governance systems in the antipodes. This relationship is not always trouble free. The friction associated with the process of drafting the ACIA policy statement in the months leading up to the Arctic Council ministerial meeting in November 2004 provides a sharp reminder of the fact that the concerns of the two communities are never identical and can diverge substantially in specific cases (Nilsson, 2007: chap. 5). But this case also demonstrates that the polar regions have emerged as key venues for the development of new practices regarding the science-policy interface that are now producing major shifts in our thinking about the interactions between the science community and the policy community with regard to efforts to govern complex systems on a large scale.

THE FUTURE OF SCIENCE DIPLOMACY

In its 2010 report on science diplomacy, the Royal Society observes that "interest in science diplomacy is growing at a time when international relations are changing" (Royal Society, 2010). No one expects the state to wither away during the foreseeable future as the basic element of international society. Yet the role of civil society is growing as a force to be reckoned with in determining the trajectory of world affairs. We know that this is the case with regard to the influence of corporations and environmental nongovernmental organizations (Pattberg, 2007). But the science community has emerged also as an important force in a wide range of issue areas. Sometimes, this is a matter of enhancing human capabilities in ways that lead to the emergence of new issues on the policy agenda, as in the cases of the development of nuclear weapons and the creation of genetically modified organisms. In other cases, scientific advances help to solve problems, as the successful effort to stamp out smallpox and the development of alternatives to ozone-depleting substances attest.

Although it is true that the cultures of science and policy making differ sharply in some respects (Royal Society, 2010), the experiences of recent decades in both the Antarctic and the Arctic suggest that science can thrive in settings involving extensive interactions between the science community and the policy community. Taking advantage of the resultant opportunities and steering clear of the potential pitfalls requires sophistication and vigilance on the part of leading members of both communities. But success in this realm is perfectly possible. Perhaps the broadest legacy of the first 50 years of the ATS is the development of a suite of practices that are useful in any effort to ensure that interactions between science and policy produce positive results for both communities in addressing a wide range of large-scale issues for the benefit of humankind and the world we inhabit.

NOTES

1. Antarctica is a transitional case in these terms. Although the territorial claims of the seven claimant states still exist on paper and are protected under the terms of Article IV of the 1959 Antarctic Treaty, Antarctica has emerged in practice as an international space for the purposes of governance.

2. Terms in measures that have been adopted by the Antarctic Treaty Consultative Parties can be comprehensively discovered and integrated from 1959 to 2007 with the Antarctic Treaty Searchable Database, 8th ed., http://aspire.tierit.com. Adopted measures in the Antarctic Treaty System also can be searched through the Antarctic Treaty Database, http://www.ats.aq/devAS/info_measures_list.aspx, from the Antarctic Treaty Secretariat.

3. Formally, SCAR is an ICSU committee, and IASC is an international associate of ICSU.

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