

King George Island and SCAR Science

Purpose

The purpose of this note is to provide a basis for a dialogue between SCAR and COMNAP on ways in which national operations by COMNAP operators on King George Island (KGI)(appearing as 'Isla 25 de Mayo' on Argentine maps) might make a greater contribution to achieving the goals of SCAR's scientific programs. The development of the note was stimulated by discussions between the SCAR and COMNAP Executive Committees at their joint meeting in St Petersburg, Russia in July 2008. The COMNAP meeting in August 2009 is a first opportunity to begin this dialogue.

Background

The Scientific Committee on Antarctic Research (SCAR) is a leader and facilitator of international Antarctic science. As such SCAR has agreed to explore with COMNAP ways in which individual scientists and national operators might improve coordination of science activities across King George Island (KGI) in the interest of encouraging a greater contribution from KGI activities to achieving the goals of SCAR scientific programs. It is recognized that the interests and prerogatives of national operators must remain sacrosanct. However, a coordinated and standard approach to data gathering, observations, logistics and utilization of infrastructure would benefit all parties operating on King George Island as well as SCAR's science programs.

There are scientific as well as economic and environmental protection imperatives for national Antarctic programs to work closer together in partnership (See separate paper on "Antarctic Science in the 21st Century"). This present paper explores the opportunities presented by the densest concentration of national programs in Antarctica – King George Island (KGI). KGI and its complex of infrastructure, stations, logistics, and scientific programs provide a unique opportunity to explore how cooperation across Antarctica and the Southern Ocean might benefit from closer coordination. This paper explores the scientific benefits to be derived from joint programs, coordination, and cooperation at KGI, as the basis for discussions with COMNAP about possible next steps.

At the outset, it is recognised that there are already good examples of scientific cooperation between different operators on KGI, for example: in creating an archive of meteorological and upper air data; in analysing climate parameters; in coordinating glaciological research on the age of the KGI ice cover; in conservation and environmental monitoring in Admiralty Bay; in permafrost dynamics; and in analysing sea surface temperatures. A good example of scientific cooperation is Dallmann Laboratory at Jubany Station. However, much more could be accomplished by way of contributing to the SCAR science programmes listed in Appendix I.

The King George Island Setting

King George Island is one of the South Shetland Islands. It is located close to the northern tip of the Antarctic Peninsula in the Maritime Antarctic climatic zone. Cape Horn of South America is about 900 km to the north. The island is dominated by a

pervasive ice cap. More than 90% of the island is glaciated. The ice-free areas and coastal zones of the island carry a diverse plant and animal life including penguins, seals, petrels and relatively rich tundra vegetation. The following descriptions of Admiralty Bay on King George Island are taken from the plan for an Antarctic Specially Managed Area (ASMA No.1) and are provided as illustrative of the larger KGI area. Admiralty Bay is typical of bay/fjord settings in the South Shetland Islands in general. The ice-free areas within Admiralty Bay are formed by recent and raised pebble-cobble beaches, recent and sub-recent moraines, mountainous peninsulas, rocky islets, spurs and nunataks. The terrain is heavily shaped by glacial and coastal marine processes. The area of Admiralty Bay is representative of the terrestrial, limnic, coastal, near-shore, pelagic, and fjord bottom ecosystems of King George Island. Plants are mostly mosses (about 70 species), liverworts (22 species), and two flowering plants, and fungi and lichens (almost 300 species) are common. Twenty-four species of birds and six species of pinnipeds have been identified in the area, but only thirteen species of birds and three species of pinnipeds breed in Admiralty Bay. The bay ecosystem reflects the general environmental conditions prevailing in the South Shetland Islands, with rocky shores covered by extensive subtidal macroalgal communities. There is a unique site, Napier Rock, at the entrance of Admiralty Bay, where a rich and highly diverse benthic invertebrate fauna is found. Fish are represented by fifteen species of Nototheniidae.

Human Activities on King George Island

King George Island is the site to the greatest concentration of national research activities in Antarctica. Human activities on the island are based on nine permanent stations and an airstrip maintained by the Chilean Air Force. Human activities on KGI date to the early 19th century, when the first sealers arrived. Within a few years the fur seal and sea elephant populations were harvested almost to extinction. At the beginning of the 20th century whalers used the island's natural harbors and sheltered beaches. Whale bones can still be found on many KGI beaches. Today the following nations have a presence on KGI – those with asterisks have permanent stations on the island: Chile*, Argentina*, Poland*, Germany, Uruguay*, Brazil*, Peru, Ecuador, China*, Korea*, and the Russian Federation*. Others like the Netherlands, UK and USA may also carry out research on the island.

King George Island and SCAR Science

Scientific activities on KGI include: meteorological, hydrological, geophysical, biological, geological, sea ice, greenhouse gases, and glaciological research. Many features of KGI are of considerable scientific interest and of direct relevance to SCAR scientific activities and programs. Existing and future research efforts on KGI have the potential to significantly contribute to SCAR science. The SCAR KGI Geographical Information System (GIS) provides a framework to integrate collected data and information. The studies being conducted in and around KGI have been broadly categorized below as pertaining to the geosciences, the life sciences, or the physical sciences (as defined by SCAR), as the basis for analyzing how KGI activities might contribute to SCAR scientific programs. It is recognized that many of the countries that conduct research on KGI are also active participants in SCAR science projects and partnerships, and so the desired linkages may already exist in some cases.

Life Science - Research into marine and terrestrial biology, including physiology and adaptation of Antarctic fish and krill; taxonomy and ecology of marine benthic fauna and

flora (micro- and macro-algae), vascular plants, mosses and lichens; terrestrial and marine ecology; and migration and dispersion of birds is being conducted on KGI. There is also a CliCOPEN project on the response of marine and terrestrial ecosystems to deglaciation related to regional warming. A long-term research project on the biology and dynamics of bird populations (mainly Pygoscelid penguins) has been carried out by the US Antarctic Program since 1976. There has also been routine collection of data on the distribution and reproduction of the Southern Giant Petrel and on skuas on KGI.

A good example of scientific collaboration is provided by the Argentine-Germany joint-managed laboratory (Dallmann), which has operated at Jubany Station since 1994 as the first bi-national facility in Antarctica. This facility operates from September to March each year to allow development of joint scientific projects (which include also scientists from the Netherlands). The main focus of research is on the communities of the marine terrestrial transition zone and the shallow water environment of Potter Cove.

These studies are particularly relevant to the science of the SCAR Standing Scientific Group on the Life Sciences, including its Expert Group on Birds and Marine Mammals and its Scientific Research Program on Evolution and Biodiversity in the Antarctic (EBA). In the broadest sense these KGI studies and data can support the overall EBA objectives of understanding the evolution and biodiversity of life in the Antarctic and identifying science outcomes relevant to the conservation policies of the Antarctic Treaty System. Depending on the quality, methodologies and the duration of KGI studies, they may also inform EBA's objectives of understanding how evolution and diversity have led to the present status of ecosystems in the Antarctic and how these ecosystems will respond to future change.

The EBA research agenda would benefit from inclusion of marine and terrestrial biological and ecological data from KGI in addressing the following scientific objectives:

- Determining the spatial and temporal variations in diversity at different spatial scales within the Antarctic and within defined time frames.
- Understanding the ability of Antarctic organisms to cope with daily, seasonal and longer-term environmental changes.
- Study of ecological responses to latitudinal and environmental gradients on local, regional and global scales.
- Discerning the role of natural and anthropogenic dispersal processes in gene flow and population structure.
- Understanding interactions between introduced and indigenous species, the effects of abiotic change on biota, and how environmental change and organism responses are linked to climate.

As a matter of course, KGI terrestrial and freshwater biological data should be deposited with SCAR's Antarctic Biodiversity Database at the Australian Antarctic Division (<http://data.aad.gov.au/aadc/biodiversity/>). KGI marine biological data should be deposited with SCAR's Marine Biodiversity Information Network (SCAR-MarBIN) in Belgium (<http://www.scarmarbin.be/>). SCAR-MarBIN is a distributed system of interoperable databases, forming the Antarctic Regional Node of the international Ocean Biogeographic Information System (OBIS), and is also part of the Global Biodiversity Information Facility (GBIF). KGI biological and ecological data is also of relevance to the CCAMLR Ecosystem Monitoring Program (CEMP) and the work of the SCAR Scientific

Committee on the Antarctic Treaty System that deals with the protection status of various Antarctic species. Offshore biological studies can (and some do) also contribute to SCAR's Census of Antarctic Marine Life (CAML) project.

Geosciences - Studies on King George Island include geology, geophysics, and paleontology, along with glacio-marine sedimentation in Admiralty Bay. These various studies could contribute to the science programs of SCAR's Standing Scientific Group on Geosciences. Indeed, the magnetic data are already made available to SCAR's Antarctic Digital Magnetic Anomaly Project (ADMAP).

A year-round seismic and Earth-magnetism observatory, established at Arctowski Station in 1978, was the first station of its kind in the South Shetland Islands. Studies on geomagnetism have been conducted at Ferraz Station since 1984. A permanent seismic observatory has been running at Jubany Station since 2004, as part of the Antarctic Seismological Argentina-Italy Network (ASAIN). These studies have relevance to the new SCAR Scientific Research Program on Solid Earth Responses and Influences on Cryosphere Evolution (SERCE), which includes a consortium to improve the coverage of many different kinds of geophysical data across the polar regions of the Earth, and incorporates the IPY POLENET project.

An absolute value of gravity was determined for the first time in KGI in Dec. 1997 at Jubany station. Two geodetic GPS sites, DAL1 (1995) and DALL (1997), were integrated into several SCAR Epoch GPS Campaigns (now SCAR Epoch Crustal Movement Campaigns). DALL performed as a CGPS (Continuous GPS) station for almost four years (1997-2001). DAL2 is the new CGPS at Jubany, operating since Feb 2003. Tide gauges were also deployed several times for geodetic purposes between 1996 and 2000 at Jubany, gathering multi-year data sets. Complementing the GPS observations, a seismological station was also deployed at Jubany for geodetic purposes in 1998 (for several months), for better understanding of regional geodynamic behavior.

The most spectacular terrestrial evidence of Antarctic cryosphere formation crop out on King George Island, including the tillite of the alpine Eocene glacial event in Harve Cove, the early Oligocene glacial and glacialmarine sediments of the Polonez Formation, and the Miocene glacialmarine diamictic of the Melville Formation (investigated recently in the SCAR's IPY project on Antarctic Climate Evolution - ACE).

Physical Sciences – KGI is undergoing dramatic glacier recession and environmental change. The glaciological setting of King George Island and the predominance of an ice cap make it an ideal location for glaciological and climate change studies. Short- and long- term climate and weather observations and information from ice cores complement SCAR science programs of the Standing Scientific Group on Physical Sciences as elaborated below.

A meteorological station has been operational at Arctowski since 1977 and at Ferraz Station since 1984 collecting basic data and to support logistic operations. Research on upper atmosphere winds is being developed at Machu Picchu Station using MST radar. Meteorological and climate data for KGI, the Antarctic Peninsula, and southern South America are important to regional climate models for climate forecasts for the Antarctic and for SCAR's Scientific Research Program on Antarctica in the Global Climate System (AGCS). KGI meteorological studies could contribute to AGCS's study of decadal time scale variability of Antarctic climate, and to the work of the SCAR Expert Group on

Operational Meteorology in the Antarctic, which is designed to assist in weather forecasting. It should be noted however that a much larger number of surface meteorological observations is being made across KGI than is needed for weather or climate forecasting. These data differ by only small amounts that reflect micrometeorological responses to local topographic variation, rather than useful climate signals. Some of the KGI data are provided routinely to the WMO Global Synoptic Network for climate studies. SCAR would welcome contributions to its meteorological READER database from all countries that have not yet made such contributions.

By far the most useful contribution KGI stations could make to SCAR's meteorological research is the provision of upper air data obtainable by balloon-launched radiosondes. Unfortunately, since Russia stopped routinely making these measurements in 1999, there have been few or no upper atmosphere measurements by radiosonde made from the island. From SCAR's perspective it is highly desirable to pursue the possibility that a regular radiosonde programme might be created on a shared cost basis between a number of operators, using the launch facilities at the Bellingshausen station.

Studies of glacial retreat (including historical documentation covering the last 50 years) and recovery of ice cores could contribute to the AGCS study of global and regional climate signals to establish better quantitative relationships between ice core data and measures of high latitude climate variability. KGI data would support the AGCS efforts to model natural and anthropogenic forcing on the Antarctic climate system, as the basis for estimating expected climate change over Antarctica during the next 100 years. Ice core records of climate change from KGI already add to SCAR's International Trans-Antarctic Scientific Expedition (ITASE) collections that are designed to study the last 200 years of Antarctic climate and environmental change.

Since February 1994 a joint Argentine-Italy programme has monitored atmospheric CO₂ concentrations at Jubany Station, taking 2 samples per second during the whole year.

Studies on the ionosphere and astrophysics have been conducted at Ferraz Station since 1984. These studies are relevant to the SCAR Research Program on Interhemispheric Conjugacy Effects in Solar-Terrestrial and Aeronomy Research (ICESTAR).

Environmental Protection - A comprehensive study of the state of the environment in the area is under way at Ferraz Station including analysis of biotic and abiotic variables. Results from this KGI program will serve as a baseline for future monitoring and for implementing environmental management of the ASMA. These studies will also inform ongoing discussions about the design of monitoring programs now before the Committee on Environmental Protection (CEP) of the ATS.

As a location of intense human activity and known disturbance, data and observations of contaminants at KGI are relevant to the work of the SCAR Expert Group on Environmental Contamination in Antarctica. Visitors to KGI are included into the monitoring carried out in the framework of the IPY-ALIENS project on invasive species.

Summary

The opportunities for KGI operations to support and enhance SCAR science programs are many and varied. Close cooperation between KGI operators and SCAR science

programs will add value to KGI studies by providing a regional, continental and global context for interpretations and comparisons. Standardized techniques and measurements, common sets of variables, and open access to data will be essential for cross-comparison of data sets from diverse locations and scientific teams not only at KGI but also more broadly in Antarctica. Because of the extensive life science, geoscience, and physical science studies being conducted at KGI, inter- and multidisciplinary integration is possible that cannot be achieved at most other locations. Unforeseen synergies and assimilation of coordinated scientific research will most assuredly be an outcome of closer collaboration, coordination, and partnership. These outcomes will benefit all national programs on KGI, as well as SCAR. Mutually beneficial cooperation and partnerships can be realized at KGI if duplication of efforts is minimized, infrastructure and logistics are shared to reduce costs and impacts, and standard techniques and sets of variables are agreed between national scientists collaborating with each other and with SCAR science activities. The realization of these opportunities can only occur if there is a desire for mutually beneficial partnerships and if bi- and multi-lateral agreements to advance common goals can be negotiated. SCAR is ready to assist operators and national scientists in moving forward for the benefit of the wider scientific community.

APPENDIX I

SCAR SCIENTIFIC ACTIVITIES (for details see <http://www.scar.org/researchgroups/>)

Standing Scientific Group on Geosciences

ACE: Antarctic Climate Evolution

ADMAP: Antarctic Digital Magnetic Anomaly Project

GIANT: Geodetic Infrastructure of Antarctica

IBCSO: International Bathymetric Chart of the Southern Ocean

PPS: Permafrost and Periglacial Environments

SALE: Subglacial Antarctic Lake Environments (joint with life sciences, below)

SERCE: Solid Earth Responses and Influences on Cryosphere Evolution

SIeGE: Sub-Ice Geological Exploration

Standing Scientific Group on Life Sciences

BAMM: Birds and Marine Mammals

CAML: Census of Antarctic Marine Life

CPR: Continuous Plankton Recorder

CSHM: Cold Seeps and Hydrothermal Mounds

EBA: Evolution and Biodiversity in the Antarctic

HBM: Human Biology and Medicine

MarBIN: Marine Biodiversity Information Network

PCPBEA: prediction of Changes in the Physical and Biological Environment of the Antarctic (joint with SSG-PS – below)

Standing Scientific Group on Physical Sciences

AAA: Antarctic Astronomy and Astrophysics

AGCS: Antarctica in the Global Climate System

ASPeCt: Antarctic Sea Ice Processes and Climate

ECA: Environmental Contamination in Antarctica

GWSWF: GPS for Weather and Space Weather Forecasting

ICESTAR: Interhemispheric Conjugacy Effects in Solar-Terrestrial and Aeronomy Research

IPICS: International Partnerships in ice Core Science

ISMALSS: Ice Sheet Mass Balance and Sea Level

ITASE: International Trans-Antarctic Scientific Expedition

Oceans: SCAR/SCOR Oceanography Group

OpMet: Operational Meteorology

PACT: Polar Atmospheric Chemistry at the Tropopause

PAntOS: Pan-Antarctic Observing Systems Network