Vol 24, November 2007

NEWSLETTER FOR THE

Canadian Antarctic Research Network

Inside

Measuring Crustal Motion in Antarctica: GPS, Tectonics, and Glacio-isostatic Adjustment 1

RUGBY (Research on Ultraviolet and Global warming effects on Biological pump Yields) 8

Canadians in Antarctic Place-Names: Supplement 13

Protocol for Canada–Argentina Collaboration 16

Canadian Involvement in Antarctic Tourism Research: an update on some recent activity 17

News in Brief 19

Measuring Crustal Motion in Antarctica: GPS, Tectonics, and Glacio-isostatic Adjustment

Thomas James

For five weeks in early 2006, I joined the U.S. National Science Foundation's (NSF) field team of the Transantarctic Mountain Deformation (TAMDEF) project (www.geology.ohio-state.edu/tamdef/) measuring crustal motion in the Transantarctic Mountains near McMurdo Station (Fig. 1). My initial involvement in this was as a modeller of the crustal motions expected from past and present changes in the Antarctic ice sheet. By observing and modelling these motions, known as glacio-isostatic adjustment (GIA), we learn about the structure and properties of the Earth beneath the TAMDEF region, and may possibly discern new features of the ice-sheet history. In turn, well-constrained GIA models allow better interpretation of remote-sensing data to determine the mass balance of ice sheets and the contribution that ice sheets make to sea-level change.

The Transantarctic Mountains are adjacent to the West Antarctic Rift System, a broad zone which has experienced significant extension in the past. When TAMDEF started, an issue in global tectonics was whether West Antarctica and East Antarctica were moving relative to one another, or whether the continent moves as a relatively rigid block. The nature and magnitude of horizontal tectonic deformation in the TAMDEF region is a related question close to the heart of Terry Wilson, a structural geologist and the TAMDEF project leader.

Terry, a professor at the Byrd Polar Research Center of Ohio State University (OSU), and Ian Whillans, a Canadian glaciologist at OSU, initiated the TAMDEF project in the fall of 1996. I met Ian at a glaciology meeting focusing on West Antarctica in the early 1990s. He was clearly intrigued at the idea of measuring crustal motion to better understand ice-sheet history. Unfortunately, Ian passed away in 2001, but the project continued under Terry's guidance, with help from Larry Hothem of the U.S. Geological Survey.

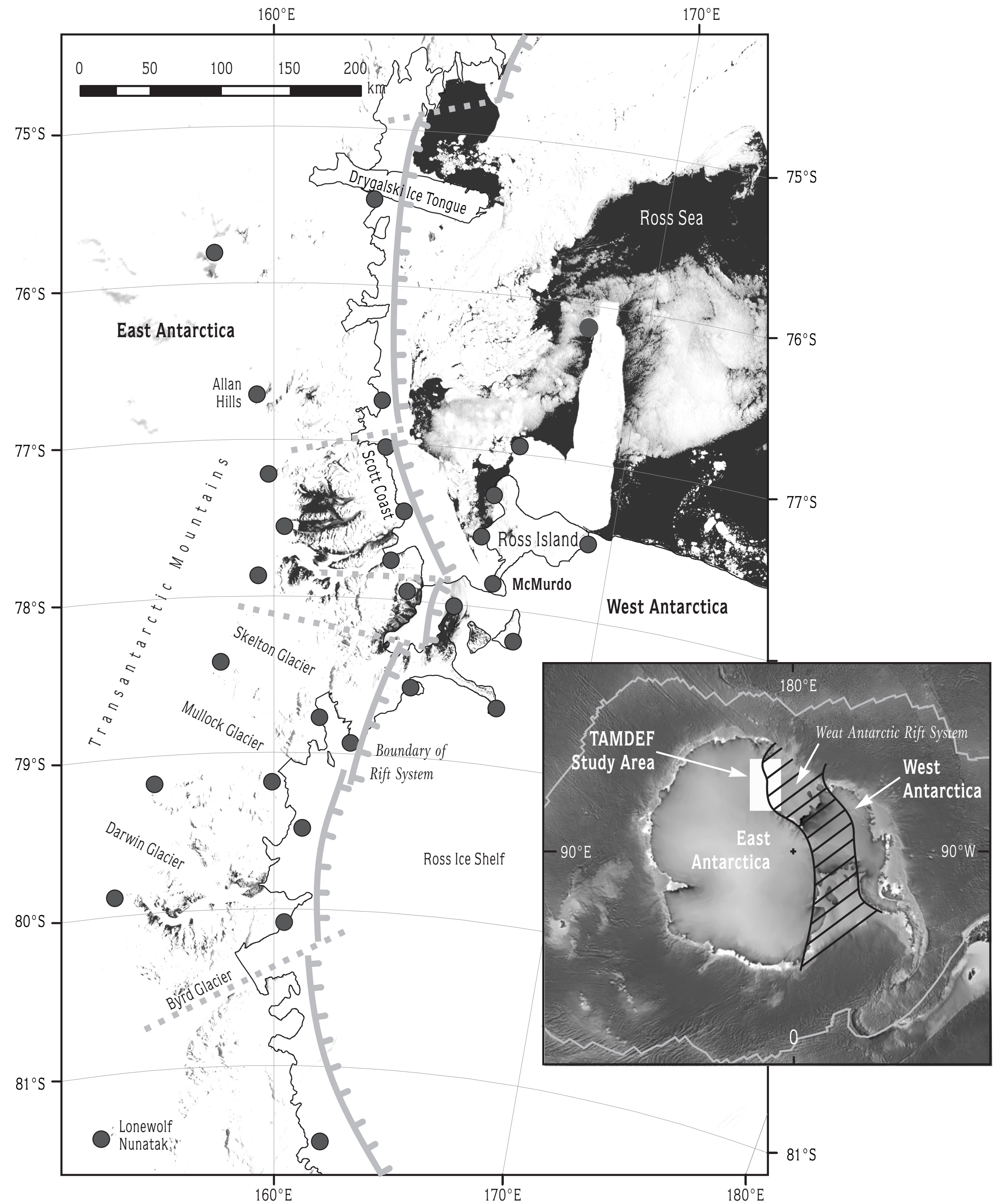

Figure 1

TAMDEF area with GPS sites (circles). (Inset) TAMDEF straddles the boundary between East and West Antarctica.

McMurdo is the main U.S. Antarctic base. In the summer its population swells to more than 1000 people. It was established in 1957/58 by the U.S. Navy for the International Geophysical Year and still retains the flavour of a military base. To take advantage of the 24-hour daylight, helo ops (helicopter operations) schedule night flights. During the latter part of our field season we often flew out in the evening to service our sites, sometimes returning in time for mid rats (midnight rations) in the galley (cafeteria).

We used Global Positioning System (GPS) trackers with antennae mounted on benchmarks consisting of threaded stainless steel rods cemented into holes drilled into solid rock. Most sites were only occupied during the Antarctic summer, with instrument deployment occurring in October and November and pickup in January and February. Some trackers have been augmented with solar panels and large insulated battery packs in an attempt to maintain operations through the Antarctic winter. The continuous sites also have a pillar-style monument that elevates the antenna off the ground. Early efforts to obtain continuous coverage had a spotty record, but by the end of the TAMDEF project a number of sites had been successfully operated throughout the winter.

Figure 2
Thomas James and Stephanie Konfal install a benchmark at Cape Roberts on the Scott Coast.

Our job was to pick up instruments deployed at the beginning of the summer and carry out “footprint” surveys. As well, additional benchmarks had to be installed around new continuous sites (Fig. 2). The footprint surveys were brief (one hour or so) occupations of a network of subsidiary benchmarks arrayed around the main benchmark to assess its stability.

Because this was the final TAMDEF field season, we were obliged to dismantle some of the continuous sites. This was disappointing, but there was no funding to continue operations, and the NSF strictly adheres to the environmental protocols that have been put in place for Antarctica. Unlike earlier days, material is not simply abandoned in the field when it can no longer be maintained or serviced.

The TAMDEF study area stretches about 650 km along the axis of the Transantarctic Mountains from the David Glacier and Drygalski Ice Tongue in the north to south of the immense Byrd Glacier. The closest I got to the South Pole was at Lonewolf Nunatak, about 950 km away. From McMurdo, this site is beyond helicopter range so we flew there in a Twin Otter operated by Kenn Borek Air. This Canadian firm, based in Calgary, provides Twin Otter support to the U.S. Antarctic Program. We flew to Lonewolf Nunatak twice. The first time we boomeranged; the flat light conditions that make it difficult to judge distance and depth meant we could not land. The next day we made the two-hour flight again and were able to land and dismantle the site.

In an east–west direction, the TAMDEF network reaches about 300 km from sites at sea level on the Scott Coast and Ross Island to the westernmost nunataks of the Transantarctic Mountains, which protrude above the East Antarctic ice sheet at around 2000 m a.s.l. Usually the conditions were not rigorous. We experienced temperatures ranging from −5 to −20°C for a few hours before climbing into the helicopter and flying back to McMurdo. Once, however, we were at the Allan Hills, at about 2000 m a.s.l., and the helicopter was late for pickup. It proved difficult to avoid a persistent strong wind blowing off the East Antarctic ice sheet. Later we determined that with the wind chill it was colder than the equivalent of −50°C. This hardly reached the extremes documented for Antarctica, or the Arctic for that matter, but is cold enough when there are no buildings or vehicles to duck into!

A more comfortable location is Marble Point, a helicopter-refuelling station on the Scott Coast. It is notable for good home-made food and the latest gossip on which helicopter pilots are getting "toasted" and need to head back home to Texas. Cape Royds, a short flight north of McMurdo on Ross Island, is the site of Shackleton's hut, and the staging point for his unsuccessful attempt to reach the South Pole with the British Antarctic Expedition of 1907–09 (Fig. 3). Unknown to me at the time, the hut is being restored by a New Zealand team which includes Canadian Gordon MacDonald from Victoria (see *CARN Newsletter*, Vol. 23, May 2007).

Figure 3
Shackleton's Hut at Cape Royds.

Cape Royds has an Adélie penguin rookery. In good years there can be up to 10,000 birds at this rookery, but when I visited the sea ice had not broken up for a few years because a large iceberg was protecting McMurdo Sound. The adult penguins had to travel long distances to forage at the ice edge. The mortality rate of the chicks had climbed and the population of the rookery had dropped to about 2500. The biologists who study these rookeries form strong attachments to their subjects and there was a sense of shock at the number of chicks that had died that summer when we visited in late January.

Although the TAMDEF experiment does not elicit such strong emotional reactions, some project members have dedicated much time to it. Michael Willis, Terry Wilson's student, has been involved since the second field season. He is analyzing and interpreting the TAMDEF observations for his Ph.D. (Willis and others, 2006) and working with my colleague, Stephane Mazzotti, to determine the best way to process the observations. Stephane helped with instrument deployment in Antarctica during the 2005/06 field season.

GPS observations are usually processed in daily batches using highly precise orbits provided by the International Global Navigation Satellite Systems (GNSS) Service (IGS). The daily positions (north, east, and up) are plotted in a time series and a regression determines the linear change. Other variations appear in the time series because of loading effects due to seasonal atmospheric and hydrological changes. The atmosphere introduces

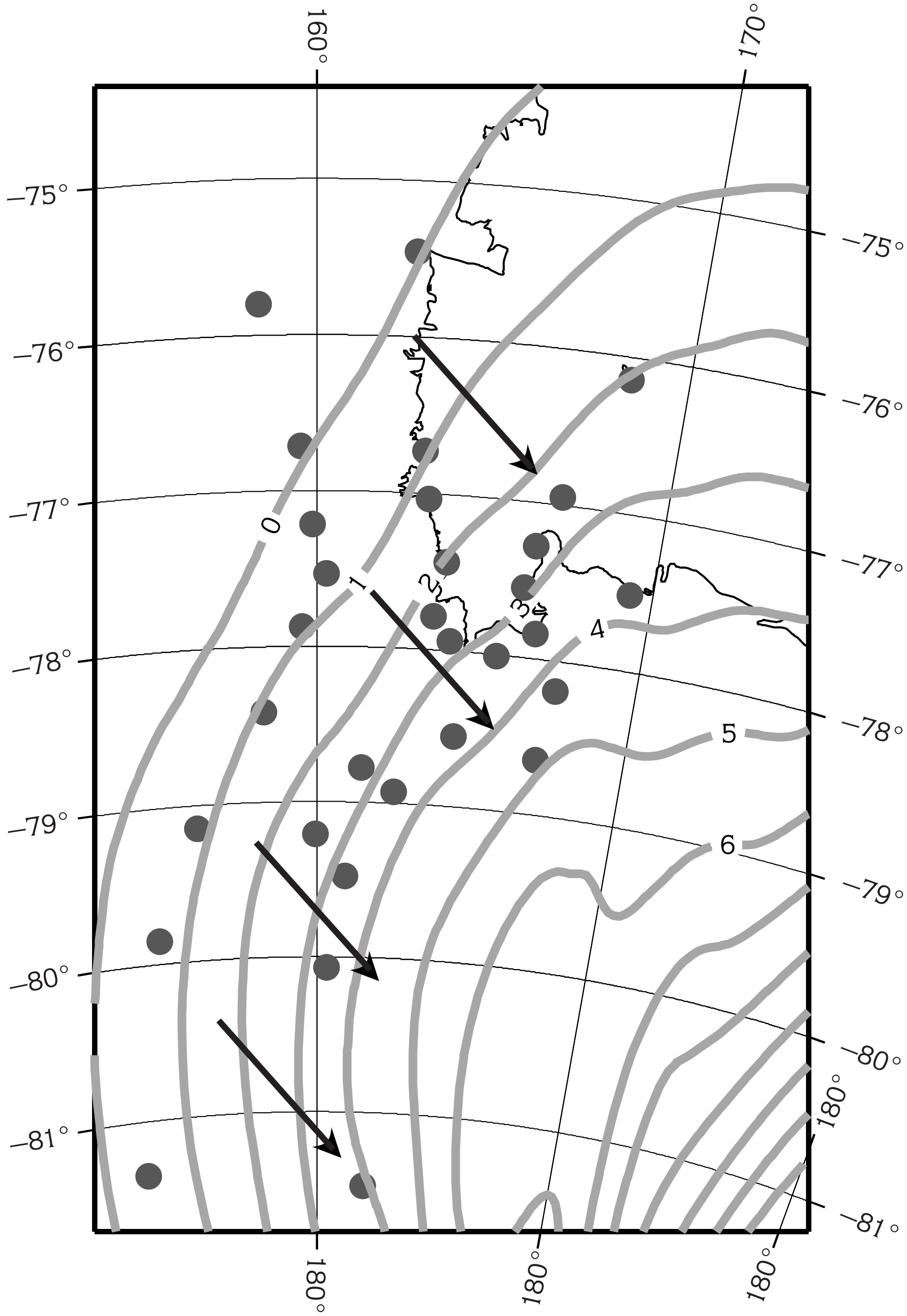

Figure 4
Predicted crustal uplift (contours in mm a^{-1}) for the IJ05 ice-history model (Ivins and James, 2005) loading an Earth model with an upper mantle viscosity of 1021 Pa s and lower mantle twice that. The arrows show the direction of horizontal motion (about 15 mm a^{-1}) of the Antarctic plate observed by the TAMDEF network.

a time-varying delay in the radio signals that are broadcast by the GPS satellites and the "tropospheric delay" has to be modelled and removed when analyzing the raw GPS observations.

The horizontal velocities observed by the TAMDEF network show motion to the southwest (Fig. 4). These are the absolute velocities, and they indicate the motion of the Antarctic plate. The TAMDEF observations of plate motion are consistent with other studies using GPS data from around the continent indicating that Antarctica moves as a relatively rigid plate, lending confidence to the TAMDEF results. When the Antarctic plate motion is removed from the observations, the residual horizontal motions are small, generally less than ~1 mm a^{-1} over the survey area. Apparently, the TAMDEF region, including the western portion of the West Antarctic Rift System (WARS), is not undergoing substantial horizontal deformation at present.

This is a surprise – Mt. Erebus, located on Ross Island, is the world's southernmost active volcano and is situated in the WARS. Crustal extension would provide a ready explanation for this volcanism – in the near-absence of present-day extension a possible explanation for the volcanism is that it is largely a relict of an earlier period of tectonic activity.

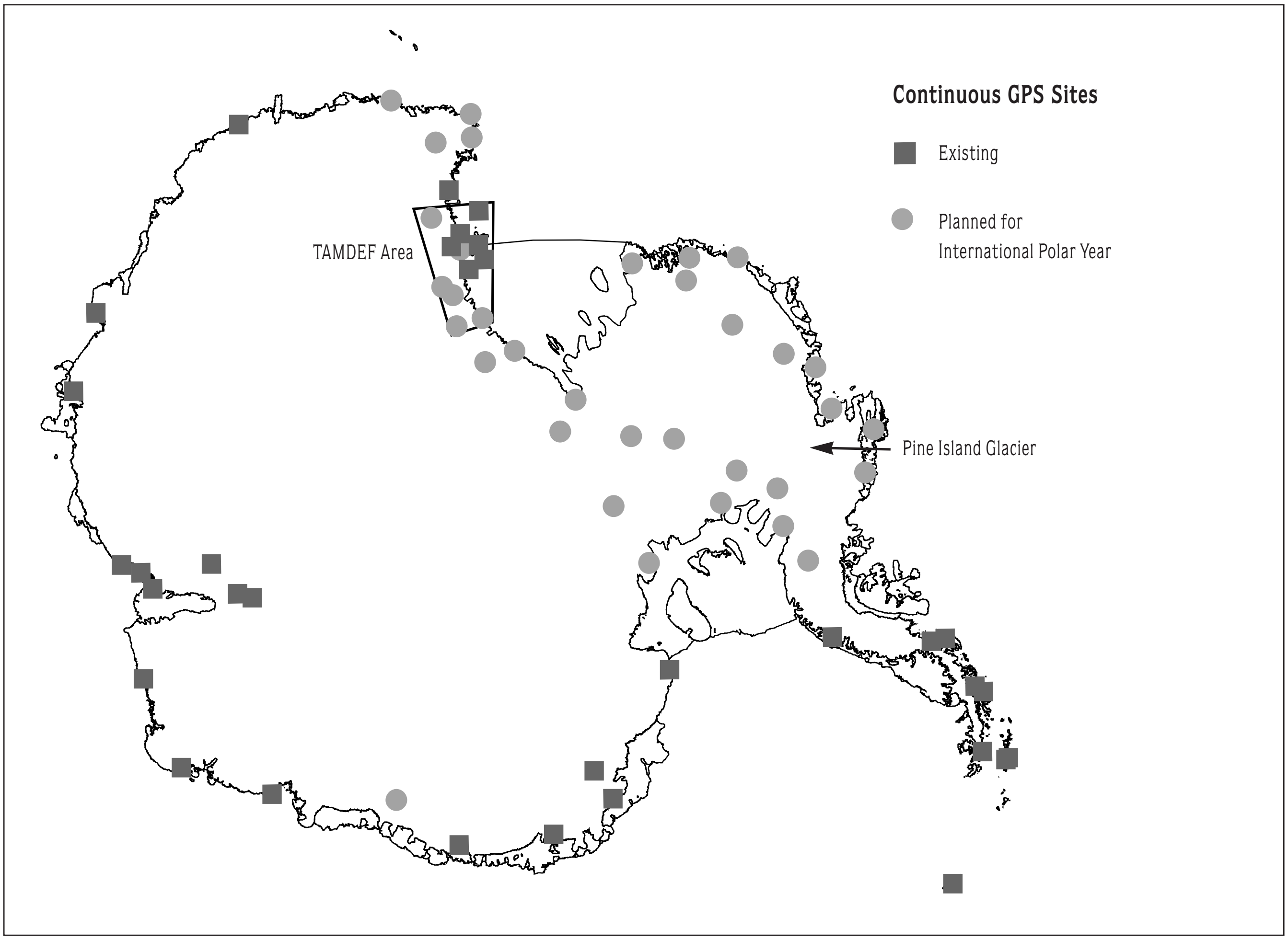

Figure 5
Planned and existing continuous GPS sites that will operate or be installed in Antarctica during IPY for the POLENET project.

Predictions of the crustal motion due to past and present-day ice-mass changes (GIA) generally feature substantial uplift rates, sometimes amounting to a cm a^{-1} or more, and much smaller horizontal rates. The uplift predictions of an Antarctic ice-history model which I recently published with Erik Ivins of the Jet Propulsion Laboratory, California Institute of Technology, are given in Figure 4. The predicted rates depend on the assumed resistance to flow, or viscosity, of the mantle. For the choice of rheology shown here, about 5 mm a^{-1} of relative vertical motion is predicted over the TAMDEF region. Mike Willis is working to determine the depth profiles of mantle viscosity, combined with possible changes to the ice-sheet loading history, that best explain the observed vertical velocities.

Geologically, East and West Antarctica are very different. East Antarctica is tectonically stable and its upper mantle is seismologically fast, suggesting that the mantle is cold and therefore more viscous. West Antarctica, in contrast, is a collection of mobile terranes underlain by seismologically slow mantle, suggesting that the shallow mantle is warm and more fluid. In support of this, West Antarctica features high crustal heat flow and has substantial volcanism. TAMDEF straddles the boundary between East and West Antarctica. There are therefore some challenges in choosing appropriate

Earth models for modelling the GIA response to explain the observed vertical motion. Preliminary indications are that a more fluid mantle (*i.e.*, lower viscosity) is required than that assumed for the predictions given in Figure 4.

Although the TAMDEF project has completed its last field season, and final analysis and interpretation is near completion, TAMDEF sites are still active (Fig. 5) as part of an expanded network. The Polar Earth Observing Network (POLENET; www.polenet.org/) is a major project of the International Polar Year (IPY). GPS and other GNSS instruments, as well as seismographs and other geophysical instruments, will be installed in both polar regions by the POLENET consortium. A number of the TAMDEF sites presently have prototype equipment for testing for POLENET, and others will be re-occupied, including Lonewolf Nunatak, which I helped to dismantle in 2006!

About two dozen nations are contributing to POLENET in Antarctica. The American POLENET effort is substantial, about $4M in funding, and will establish continuous GPS sites at many bedrock locations throughout West Antarctica. I am continuing my collaboration with Terry Wilson through the POLENET project Although some Canadians will probably participate in the 2008/09 POLENET field season in Antarctica, at present there are no Canadian funds for the purchase of instrumentation or provision of logistical support.

IPY 2007–08 is an intensive burst of internationally coordinated, interdisciplinary, scientific research and observations focused on the Earth's polar regions. Canada is a signatory to the Antarctic Treaty and a member of the Scientific Committee on Antarctica Research. Antarctic environmental changes have the potential to affect the Canadian landmass through sea-level change and climate teleconnections. Many Canadian scientists have expressed disappointment that the Canadian IPY effort is directed solely at the Arctic despite the important associations that Canada has with Antarctica and the implications that Antarctic research has for Canada.

West Antarctica hosts a large ice sheet, much of which is grounded below sea-level. Its stability has been questioned since at least the 1970s, when a portion of it, known as the Pine Island Glacier, was termed the soft underbelly of the Antarctic ice sheet. In contrast, the East Antarctic ice sheet is thought to be relatively stable and unlikely to respond quickly to environmental changes. Recent reports show an acceleration of many outlet glaciers in West Antarctica. The acceleration may be linked to warmer ocean temperatures that are thinning ice shelves and contributing to their break-up. This removes some of the buttressing that ice shelves are thought to provide to grounded ice.

Consequently, the focus of a great deal of remote-sensing activity is on the West Antarctic ice sheet to determine how quickly it is changing its size. POLENET will provide key assistance to this effort by measuring the uplift rate of the bedrock at many localities. In some cases these uplift rates will largely be due to the instantaneous response of the bedrock to present day ice-mass changes, and in other cases the uplift rate will be due to the viscous response of the Earth's mantle to past ice-mass changes (GIA). In either case, POLENET measurements are needed to correct the observations for the Earth's response and isolate the signal from the fluctuating ice sheet.

A particularly important POLENET application is for the Gravity Recovery and Climate Experiment (GRACE) satellite gravity mission, which is taking snapshots of the Earth's gravity field. The gravity snapshots are equally sensitive to mass changes within the Earth (such as from GIA) and mass changes from surface hydrology, such as from ice sheets. GRACE has detected a large gravity change anomaly in the region of Pine Island Glacier indicative of ice mass being lost, but just how much this mass is depends on the assumptions being made about the Earth's response to past ice changes. This poses an important scientific question that could be addressed through the installation of one or two additional sites around Pine Island Glacier. It would be nice to think that there could be a substantive Canadian contribution to this IPY activity, but time is running out because the planning for the 2008/09 field season will be well advanced by June 2008.

References

Ivins, E.R. and T.S. James. 2005. Antarctic glacial isostatic adjustment: a new assessment. *Antarct. Sci.*, **17**(4), 541–553.

Willis, M.J., T.J. Wilson and T.S. James. 2006. Bedrock motions from a decade of GPS measurements in southern Victoria Land, Antarctica. [Abstract.] *Eos, Trans. AGU*, **87**(52), Fall Meet. Suppl., G33B-0059.

Wilson, T.J. and D. Wiens, Polar Earth Observing Network for the International Polar Year (Powerpoint presentation www.polenet.org/polenet_meet_isaes_2007.htm).

Dr. Thomas James (tjames@nrcan.gc.ca) is a research scientist at the Geological Survey of Canada, Natural Resources Canada, and an adjunct professor at the University of Victoria and Ohio State University. This is Earth Sciences Sector contribution number 20070454.

RUGBY
(Research on Ultraviolet and Global warming effects on Biological pump Yields)

Serge Demers, Gustavo Ferreyra and the RUGBY participants

Despite natural long-term cycles in concentrations of atmospheric carbon dioxide, it is now widely accepted that the contemporary substantial and rapid increase of this gas is largely a result of human activity. CO_2 is considered to be one of the primary anthropogenic greenhouse gases responsible for global warming, followed by methane, halocarbons and nitrous oxide. Oceans play a key role in CO_2 dynamics. Recent estimates for 1800–1994 show that the ocean sink of CO_2 represents ~48% of human-generated fossil carbon burning and cement-making emissions. These man-made emissions supposedly lead to an increased flux of CO_2 between the atmosphere and the ocean, partly controlled by physical processes. However, a significant fraction of this gas, once in the upper layer of the water column, is fixed by plant photosynthesis; ~45 gigatons of carbon per year, of which ~16 Gt is estimated to be exported to the deep ocean where it is immobilized.

The main focus of this research program is the biological incorporation of CO_2 into the water column, as well as cycling and the export of particulate and dissolved carbon (POC and DOC, respectively) to the bottom of the ocean and to deep waters, a process known as the biological pump (Fig. 1); a process basically controlled by the balance of two key mechanisms: *photosynthesis* and *respiration.*

Photosynthesis is the process used by certain organisms to transform inorganic carbon (in the form of CO_2) into organic carbon. It occurs exclusively at depths reached by light, defined as the “euphotic zone.” This process is limited to plants, from microscopic (phytoplankton) to macroscopic (macroalgae), and requires access to nutrient salts.

In contrast, *respiration* is a process that involves both plants and all consumers, from the smallest bacteria to the largest animals, throughout the water column.

Whether these two processes are balanced or not on the global ocean scale is still under debate. At present, several issues are topics of great concern for the international scientific community. Among these are variations in CO_2 fluxes, such as the exchange of this gas between the atmosphere and the ocean, and the effects of climate warming on the planet and ultraviolet B radiation (UVBR, 280–320 nm), which strongly influences photosynthesis and respiration in the upper layer of the oceans.

As is well known, UVBR, which is highly harmful for living organisms, has increased during the last decades, due to the destruction of the stratospheric ozone layer, mainly in the polar regions. On the other hand, the increase of CO_2 levels in the atmosphere has contributed to the global rise of Earth’s temperature.

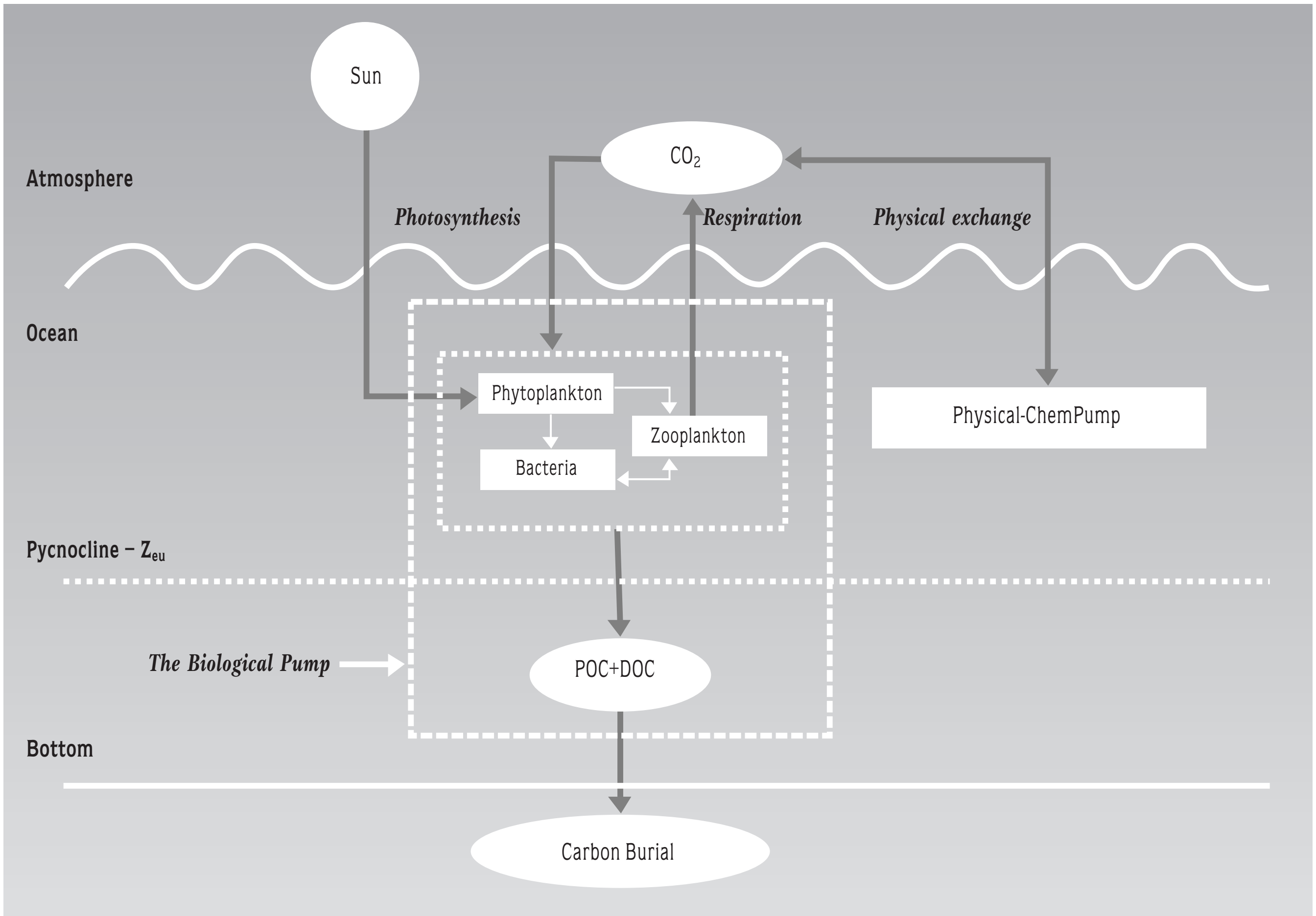

Figure 1
The biological pump.

The combined influence on marine plankton communities of increased UVBR and climate change is still unknown. It might modify the dynamics of carbon fluxes between the ocean surface waters and the deep ocean. These fluxes depend not only on the physical and chemical characteristics of seawater, but also on biological factors, *i.e.*, the type of plankton communities present.

The present research project is studying the combined effects on the planktonic community of climate warming, the increase of CO_2 and UVBR, and how resultant modifications in the planktonic system might affect atmosphere–ocean CO_2 fluxes and the biological pump (Fig. 2).

Planktonic organisms, particularly photosynthetic ones, are found at relatively shallow depths, due to water-column density stratification. Warmer and fresher waters lie over colder and saltier waters, generating a density gradient which is called a *pycnocline.* Pycnoclines limit the exchanges of small organisms, gases and chemical substances between both layers of water. Physical factors like winds mix the water above the pycnocline, thus forming an *upper mixed layer.*

Global warming is expected to reduce the average depth of the upper mixed layer, hence increasing the degree of exposure of the plankton community to UVBR. Therefore, the central questions to be answered through this research are:

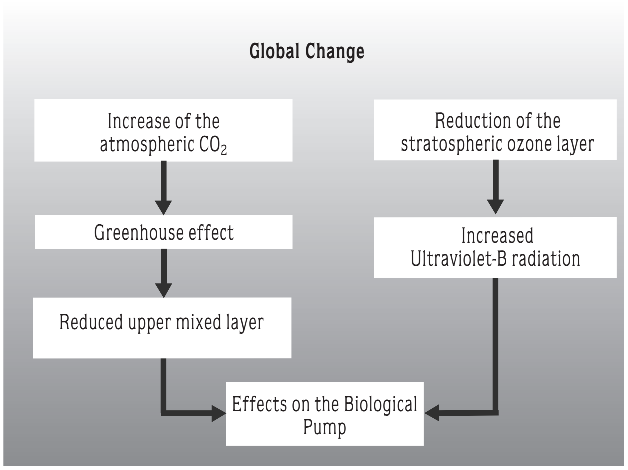

Figure 2.
Factors affecting the biological pump.

(1) what is the global response of the biological pump to higher levels of UVBR and global warming?
(2) will there be significant changes in the atmosphere–ocean CO_2 fluxes related to changes in the plankton community?
(3) what will be the magnitude of these changes and the consequences for the rest of the marine ecosystem?

To carry out this project, several procedures will be used to obtain field and experimental data. These include keeping continuous records of environmental variables, such as visible and ultraviolet radiation at the sea surface and through vertical profiles in the water column, together with salinity and temperature profiles. Water samples are taken at specific depths and intervals both in the field and during mesocosm experiments. Mesocosms are parcels of the water column contained in large enclosures, usually >1 m^3, which

Figure 3.
Research vessel *Sedna IV*.

are considered to represent the characteristics of the natural systems under study.

These samples will be used to study a series of key variables: plankton composition and abundance, photosynthetic pigments, photosynthesis and respiration, photoprotective substances, water chemistry, particulate organic carbon (POC), particulate organic nitrogen (PON), and also the synergic effects of pollutants such as hydrocarbons. Once back in Canada, several of these parameters will be monitored, through highly complex equipment (*e.g.*, HPLC, flow cytometer, etc.).

Finally, all data will be integrated into mathematical models that will help explain the processes studied, as well as providing the basis for describing possible future global-change scenarios.

The general project consists of four different fieldwork campaigns, starting with the research vessel *Sedna IV* field mission (Fig. 3). The research is divided as follows:

2005–06: Two latitudinal studies will be carried out along inter-hemispheric Atlantic Ocean transects, based on samples taken along the track of the *Sedna IV*, from Canada to the Antarctic and during its recent return voyage to Canada. One time-series will be based on samples collected and parameters analyzed during the wintering-over period at the Melchior station.

2007: A scientific cruise in December 2007 on the Argentine oceanographic ship A.R.A. *Puerto Deseado* (Fig. 4) in the area of the western Antarctic Peninsula, in collaboration with the Dirección Nacional del Antártico Instituto Antártico Argentino (DNA-IAA).

2008: A mesocosms experiment at the Esperanza station (DNA-IAA-Ejército Argentino) (Fig. 5) in January 2008 to study the effects of ultraviolet radiation and increased temperature on the biological pump.

A second mesocosm experiment, in August 2008, similar to that performed at Melchior in 2007, in the Arctic at the Nunavik Whapmagoostui–Kuujjuarapik research station (55°17'N, 77°46'W, Centre d'Études Nordiques, Université Laval).

The project is scheduled to be finished by the end of 2009. Five doctoral theses, several publications in specialized journals and presentations to scientific meetings are expected within this period. The results will increase our knowledge of this issue, which is of general concern, and will also raise awareness in the general public about the need to protect the planet.

The investigations described here have been made possible by a collaboration between Canadian and Argentine government agencies. This was initiated in 2001 by the Institut des Sciences de la mer de Rimouski of the Université du Québec à Rimouski (UQAR-ISMER) from Canada,

Figure 4.
Argentine oceanographic ship A.R.A. *Puerto Deseado*.

Figure 5.
Esperanza station.

Figure 6
Mission accomplished!

and the Dirección Nacional del Antártico–Instituto Antártico Argentino (IAA) from Argentina (see article in this issue, p. 16).

Three scientific institutions are part of this International Polar Year project: IAA, ISMER and the University of Victoria. In Canada, financial support for scientific activities and human resources has been provided by the Natural Sciences and Engineering Research Council, the Ministère du

Développement économique, de l'Innovation et de l'Exportation du Québec and the Economic Development Agency of Canada for the Regions of Quebec. Argentina provided logistical support, coordinated by DNA-IAA. This support included transportation of cargo and personnel from Argentina with Air Force aircraft to the Marambio station at the northern tip of the Antarctic Peninsula (64°14'42"S, 56°39'25"W). Also, transfer to the icebreaker A.R.A. *Almirante Irízar* was provided by Argentine Navy helicopter, as well as the transfer of crew members to *Sedna IV* at Melchior in March 2006. In February 2006, the icebreaker delivered fuel and food to *Sedna IV* for the winter. Meanwhile, Navy personnel took care of repairs and maintenance of the Melchior facility, for our use as a field laboratory. The U.S. National Science Foundation generously transported an important part of the scientific cargo on its icebreaker R/V *Laurence M. Gould*, following a request from the DNA-IAA.

This is a multidisciplinary project, integrating physical, chemical and biological oceanographers. The RUGBY team consists of a project leader (Dr Serge Demers), one scientific coordinator (Dr Gustavo Ferreyra, gferreyra@dna.gov.ar), five principal investigators (Dr Suzanne Roy, suzanne_roy@uqar.qc.ca; Dr Émilien Pelletier, emilien_pelletier@uqar.qc.ca; Dr Huixiang Xie, huixiang_xie@uqar.qc.ca; Dr Karine Lemarchand, karine_lemarchand@uqar.qc.ca; and Dr Eddy Carmack, carmacke@pac.dfo-mpo.gc.ca), one research collaborator (Dr Fernando Momo, fmomo@ungs.edu.ar), four post-doctoral researchers (Dr Irene Schloss, irene.schloss@uqar.qc.ca; Dr Damián López, jamerboi@stratosnet.com; Dénis Brion, denis_brion@yahoo.ca; Marie Lionard, marie_lionard@yahoo.fr), three doctoral students (Sébastien Moreau, sebastien.moreau@uqar.qc.ca; Sébastien Roy, bass.roy@stratosnet.com; Xiaomeng Huang) and one master's student (Bernard Mercier, bernardmercier99@hotmail.com). Other doctoral students (from both Canada and Argentina) will be recruited to complete the team, which will participate in the other aspects of the project. The research group has extensive experience in ultraviolet radiation research, and has already produced a significant number of refereed publications in international journals. Two members of the group, Damián López and Sébastien Roy, participated in the 2006–07 wintering-over program at Melchior, on the Antarctica Peninsula, as part of the team on board the *Sedna IV*.

Dr Serge Demers (serge_demers@uqar.qc.ca) is Director of the Institut des sciences de la mer de Rimouski (ISMER; www.ismer.ca) and Professor of Oceanography at the Université du Québec à Rimouski, of which ISMER is a part. Dr Gustavo Ferreyra (gustavo_ferreyra@uqar.qc.ca) is a research associate at ISMER and scientific coordinator of the project.

Canadians in Antarctic Place-Names: Supplement

C. Simon L. Ommanney

In a previous issue of the *CARN Newsletter*, Geoffrey Hattersley-Smith (2005) provided a comprehensive list of Antarctic names associated with Canada and Canadians. However, since that article was published, some of those who were overlooked have contacted me. In addition, Olav Loken has provided information on some missing names related to Canadian ships that were intentionally excluded from the previous list. Yet other names have come to my notice with the passage of time. It therefore seems timely to provide an update.

One noticeable oversight in the original list was Blackwall Ice Stream, the first Antarctic name adopted by the Geographical Names Board of Canada (Loken, 2000). Through the excellent online gazetteer of the Antarctic, maintained by Italy on behalf of the Scientific Committee on Antarctic Research, it has been possible to identify a significant number of other names with a Canadian connection. For continuity with the previous list, the numbering system applied there has been extended to the names listed below, even though a revised map has not been compiled. Two names, Tickle Channel and Sunker Nunataks, are included because they contain unique Canadian generics (Canada, 1987), used here as specifics, that reflect the heritage of some of the sailors who visited the continent.

As with the previous list, the exact locations of the features are given, the name of the person commemorated and some biographical information. Many of the Canadians commemorated were born outside Canada. Non-personal names with a Canadian association are identified in square brackets.

Information on other relevant names missing from this or the previous list should be sent to simon.ommanney@sympatico.ca.

75 **Bartlett Glacier:** 86°15'S, 152°W, a tributary to Scott Glacier. Named for Capt. Robert A. Bartlett, of Brigus, Newfoundland, noted Arctic navigator and explorer.

76 **[Beaver Glacier]:** 83°24'S, 169°30'E, a glacier draining the Queen Alexandra Range and joining the Ross Ice Shelf at McCann Point. Named after the Beaver aircraft, City of Auckland, that crashed in this area in January 1960.

77 **Blackwall Ice Stream:** 82°52'S, 35°21'W, a northward flowing tributary to Recovery Glacier that flows into the Ronne–Filchner Ice Shelf between Argentina Range and Whichaway Nunataks. Named after Hugh Blackwall Evans (1874–1975), English-born Canadian naturalist, of Vermillion, Alta, who was with the British Antarctic Expedition (BAE), 1898–1900, led by Carsten Borchgrevink in the *Southern Cross.*

78 **Burton Point:** 66°16'S, 66°56'W, northeast point of Krogh Island, Biscoe Islands. Named after Dr Alan Chadburn Burton (1904–79), English-born Canadian biophysicist, who specialized in problems of cold-weather clothing; in association with the names of pioneers of cold-climate physiology in this area.

79 **Campbell Glacier:** 74°25'S, 164°22'E, a 100-km long glacier that flows SE between Deep Freeze Range and Mount Melbourne to discharge into northern Terra Nova Bay. Named for Capt. Victor Lindsey Arbuthnot Campbell, OBE, DSO (1875–1956), leader of the Northern Party of Captain Scott's 1910–13 BAE. After retiring from the British Navy, he settled in Black Duck Brook, on Newfoundland's west coast. His diary, archived at Memorial University of Newfoundland, has been published (King, 1988).

80 **Campbell Glacier Tongue:** 74°36'S, 164°24'E, the seaward extension of Campbell Glacier into northern Terra Nova Bay. Named in association with Campbell Glacier.

81 **[Canada Peak]:** 77°37'S, 162°50'E, peak overlooking the Canada Glacier, after which it is named.

82 **Carroll, Mount:** 63°26'S, 57°03'W, mountain rising to 650 m a.s.l., south of Hope Bay, Trinity Peninsula. Named after Tom Carroll (b. 1864), Newfoundland boatswain on the *Eagle,* the Operation Tabarin relief ship, 1944–45.

83 **Doran Glacier:** 77°43'S, 162°40'E, glacier between Sollas and Marr Glaciers on the north slope of Kukri Hills, Victoria Land. Named in association with Doran Stream (see below).

84 **Doran Stream:** 77°42'S, 162°34'E, meltwater stream that flows north from an unnamed glacier east of Sollas Glacier to Priscu Stream in Taylor Valley, Victoria Land. Named after Dr Peter T. Doran, Canadian-born paleolimnologist, who has worked in the McMurdo Dry Valleys since 1993.

85 **[Eagle Cove]:** 63°24'S, 57°00'W, a small cove on the south side of Hope Bay near the tip of the Antarctic Peninsula. Named after the Newfoundland sealing vessel *Eagle,* under Master R. Sheppard, that helped establish the Falklands Islands Dependencies Service (FIDS) base at Hope Bay in 1945. (See also Sheppard Nunatak and Sheppard Point in the previous list.)

86 **[Eagle Island]:** 63°40'S, 57°29'W, a small island between Trinity Peninsula and Vega Island on the west side of the Antarctic Peninsula. Named after the Newfoundland sealer *Eagle* (see Eagle Cove above).

87 **Fred Cirque:** 72°34'S, 0°25'E, a large cirque on the side of Roots Heights (see previous list). Named after Dr Ernest Frederick Roots, OC, FRSC (b. 1923), chief geologist on the Norwegian-British-Swedish Antarctic Expedition, 1949–52.

88 **Ghent Ridge:** 77°34'S, 163°07'E, a ridge that parallels the southern flank of Commonwealth Glacier, Victoria Land. Named after Dr Edward D. Ghent, leader of the 1965–66 Victoria University Antarctic Expedition, now with the Department of Geology and Geophysics, University of Calgary.

89 **Hayward, Mount:** 78°07'S, 167°21'E, a hilll on White Island, two miles south of Mt Heine. Named for Victor G. Hayward, a Canadian member of the Imperial Trans-Antarctic Expedition (1914–17), Ross Sea Party, who lost his life in a blizzard on 8 May 1916 when the sea ice in McMurdo Sound went out.

90 **Hollick-Kenyon Peninsula:** 68°35'S 63°50'W, an ice-covered spur from the main mountain mass of the Antarctic Peninsula. Named for Herbert Hollick-Kenyon, Canadian pilot on Lincoln Ellsworth's Trans-Antarctic flight of 1935; recognized as Kenyon Peninsula by Argentina and the U.K. (see previous list).

91 **Hollick-Kenyon Plateau:** 78°00'S, 105°00'W, 1200–1800 m high, rather featureless plateau near the 'root' of the Antarctic Peninsula. Named as above.

92 **Jacobs Peak:** 80°05'S, 157°46'E, 2040 m a.s.l., in the Britannia Range, at the north end of the ridge west of Ragotzkie Glacier, north of Byrd Glacier. Named for Dr John D. Jacobs, who wintered over with the 9th Soviet Antarctic Expedition at Vostok, 1963–65, now with the Geography Department, Memorial University of Newfoundland, St. John's.

93 **Lord Nunatak:** 80°21'S, 24°01'W, a nunatak 2.5 km southwest of Baines Nunatak, in the Shackleton Range. Named after William B. Lord, Canadian artilleryman and joint author with T. Baines of *Shifts and Expedients of Camp Life, Travel and Exploration*, London, 1871; in association with the group of pioneers of polar life and travel.

94 **Marø Cliffs:** 79°04'S, 28°30'W, prominent rock cliffs southwest of Jeffries Glacier in the Theron Mountains. Named for Harald Marø, Halifax-based captain of the Canadian sealer *Theron* that was chartered by members of the Commonwealth Trans-Antarctic Expedition (CTAE) to the Filchner Ice Shelf in 1955–56.

95 **[Muskegbukta]:** 70°10'S, 2°31'W, small bay in Fimbulisen on Kronprinsesse Märtha Kyst. Probably named after the Canadian "Muskeg" tractor.

96 **[Otterbukta]:** 70°10'S 2°23'W, small bay in Fimbulisen on Kronprinsesse Märtha Kyst. Probably named after the Canadian de Havilland Otter aircraft.

97 **Perk Summit:** 77°35'S, 162°54'E, 1750 m a.s.l., the highest elevation on the ridge between Mount McLennan and Mount Keohane, in the Asgard Range, Victoria Land. Named after Henry Perk, chief pilot of Kenn Borek Air Ltd., Calgary, Alberta, who has flown the Canadian de Havilland Twin Otter aircraft in support of U.S. programs in Antarctica.

98 **Shaw Trough:** 77°32'S, 160°54'E, a primary elongate trough in the McMurdo Dry Valleys. Named after Dr John Shaw, Department of Geography, University of Alberta, Edmonton.

99 **Strathcona, Mount:** 67°25'S, 99°12'E, 1380 m a.s.l., an outstanding nunatak on the western side of Denman Glacier, in Queen Mary Land. Named by Sir Douglas Mawson for Donald Alexander Smith, Lord Strathcona and Mount Royal , G.C.M.G., G.C.V.O., High Commissioner for Canada in London from 1896 until his death in 1914, and a patron of the Australasian Antarctic Expedition, 1911–14.

100 **[Sunker Nunataks]:** 76°40'S, 161°25'E, a group of small, rounded nunataks rising through the ice on the eastern side of Northwind Glacier, and through the lowest portion of the upper Fry Glacier, in the Convoy

Range, Victoria Land, similar in appearance to a reef at sea. Sunker is a Canadian generic used to describe submerged rocks in Newfoundland and Nova Scotia.

101 **[Theron Mountains]:** 79°05'S, 28°15'W, 1175 m a.s.l., mountains extending NE–SW on the eastern side of the Filchner Ice Shelf. Named after the Canadian sealer *Theron*, the ship chartered by members of the CTAE to the Filchner Ice Shelf in 1955–56 (see Marø Cliffs).

102 **[Tickle Channel]:** 67°06'S, 67°43'W, a narrow channel in the southern part of Hanusse Bay, separating Hansen Island from the eastern extremity of Adelaide Island. Tickle is a Canadian generic used to describe narrow, treacherous, water passages in Newfoundland, and rarely in Nova Scotia and Nunavut.

103 **Vincent Creek:** 77°43'S, 162°26'E, a meltwater stream flowing from Hughes Glacier to Lake Bonney in Taylor Valley, Victoria Land. Named after Dr Warwick F. Vincent, a New Zealand limnologist, who worked in the McMurdo Dry Valleys, now with the Department of Biology, Université Laval.

104 **Whitten Peak:** 63°25'S, 57°04'W, 445 m a.s.l., pyramidal peak at the northeastern end of Blade Ridge, western side of the head of Hope Bay, Antarctic Peninsula. Named for R. Whitten, first mate of the Newfoundland ship *Eagle*, which participated in FIDS operations in 1944–45.

References

Canada, Secretary of State and Energy Mines and Resources Canada. 1987. *Generic terms in Canada's geographical names.* Ottawa, Ont., Secretary of State, Translation Bureau. Energy Mines and Resources Canada, Canadian Permanent Committee on Geographical Names (Terminology Bull. 176).

Hattersley-Smith, G. 2005. Canadians in Antarctic place-names. *CARN Newsl.*, **20**, 3–8.

Italy, Programma Nazionale di Ricerche in Antartide, 2000. *Composite gazetteer of Antarctica.* Rome, Programma Nazionale di Ricerche in Antartide and Scientific Committee on Antarctic Research, Geoscience Standing Scientific Group (http://apple.arcoveggio.enea.it/SCAR_GAZE).

King, H.G.R., ed. 1988. *The wicked mate: the Antarctic diary of Victor Campbell.* Huntingdon and Alburgh, Bluntisham Books and the Erskine Press.

Loken, O.H. 2000. Geographical Names Board of Canada approves Antarctic geographical name. *CARN Newsl.*, **11**, 11.

Simon Ommanney (simon.ommanney@ sympatico.ca) is Secretary of the Canadian Committee on Antarctic Research. For 15 years he chaired the Advisory Committee on Glaciological and Alpine Nomenclature of what is now the Geographical Names Board of Canada.

Protocol for Canada–Argentina Collaboration

On 29 November 2006, Dr Mariano Mémolli of the Dirección Nacional del Antártico (DNA), Dr Michel Ringuet of the Université du Québec à Rimouski (UQAR), Dr Serge Demers of the Institut des Sciences de la mer de Rimouski (ISMER), and Dr Sergio Marenssi of the Instituto Antártico Argentino (IAA), met in Buenos Aires to sign a protocol for collaboration between Canada and Argentina, building on a previous protocol signed on 20 August 2001.

The agreement supports scientific research in the Antarctic on the environment and related technological developments. The intent is to better understand the southern polar ecosystem, while minimizing environmental impacts resulting from the research and facilities used to study it.

The Canadian team will acquire a scientific laboratory and a bunkhouse for six scientists and technicians at the Argentine Esperanza base (see Fig. 5, p. 12) for a period of three years. There is a provision for automatic renewal of the protocol for subsequent three-year periods as long as both parties wish it.

UQAR/ISMER will provide the scientific equipment and run the buildings, but their construction and maintenance will be handled by the DNA. A management committee with three representatives from the IAA and three from ISMER will evaluate the research program and set priorities.

Because Argentina has decided that all its Antarctic bases should be carbon neutral within a decade, one major element in the new agreement requires the Canadian team to undertake a pilot project to equip the buildings with self-sufficient clean energy. Partnerships will be solicited with private-sector companies specializing in solar, wind and other alternative energy sources. The Canadian Embassy in Argentina will help identify potential partners there, but the hope is that companies based in Canada may also be interested in participating. Representatives of any companies having the appropriate technology and wishing to be considered should contact Serge Demers (serge_demers@uqar.qc.ca). The success of this pilot project could have significant economic implications for those involved, as a viable system would be of great interest, not only to those operating in both polar regions, but to those in isolated areas without access to a grid. Benefits would be shared equally by UQAR/ISMER and DNA/IAA.

Although UQAR/ISMER will be covering the principal costs of its scientists and technicians, the DNA will absorb the cost of transportation, accommodation and meals of up to a maximum of six people during operations on the Antarctic continent for a period of three months, from the point of departure in Buenos Aires.

Dr Serge Demers is to be congratulated for negotiating an agreement which provides Canadian scientists with an unique foothold on the Antarctic continent and an unprecedented opportunity for participating in, and contributing to, the critical research work being undertaken there.

Canadian Involvement in Antarctic Tourism Research: an update on some recent activity

Patrick T. Maher

Despite the distinct lack of tourism-related research projects (Arctic or Antarctic) officially linked to Canada's International Polar Year (IPY) efforts (see www.ipycanada.ca) there are a number of exciting research-related developments originating in Canada or with Canadian involvement. Globally, the lack of official tourism-related IPY research projects is quite surprising given the tremendous growth of tourism in the Antarctic and given the focus in previous IPYs (including the International Geophysical Year) on geographical exploration, which is so often a predecessor to tourism. A few important items of note follow as an update on recent Canadian activities.

The upcoming *Tourism and Global Change in the Polar Regions* conference, sponsored by the International Geographical Union, has nine Canadian presenters including myself. Being held in Oulu, Finland, from 29 November to 2 December 2007, this conference promises to be the primary polar tourism research conference during the IPY and has an excellent mix of both Arctic and Antarctic content (see: http://thule.oulu.fi/iguconference/index.html).

In October 2007, the International Polar Tourism Research Network (IPTRN) came online as a conduit for researchers, operators, students, community members and others to connect with each other via a web forum, but also to disperse research information and publications to the wider public. This network came about as a result of two sessions I organized at the 2006 Canadian Association of Geographer's (CAG) meeting in Thunder Bay, Ontario. In Thunder Bay, a small group of researchers envisioned how we might better share information and discuss the topic of

Tourists at Scott Base: Ross Sea region, Antarctica.

polar tourism. Alain Grenier, from the Université du Québec à Montréal, has since set up the practical means to do so electronically through a new network site and forum established at: www.polartourismnetwork.uqam.ca. The network formation and website has progressed from the brief news item mentioned in the *CARN Newsletter* (Vol. 23, May 2007, p. 13). Although the meeting proposed in that report did not take place, it is hoped that such an organizational meeting for the network will take place in the near future; details have yet to be determined.

A separate outcome of the 2006 CAG meeting is a special issue of *Polar Geography,* of which I am the guest editor. This issue is Arctic-specific in its content, but bi-polar in its implications. Specifically, the discussions held between presenters and the audience at the CAG meeting, and published in the introductory editorial, speak to tourism in Antarctica (www.informaworld.com/1939-0513).

Another important publication, which I guest edited in cooperation with Emma Stewart from the University of Calgary, is the forthcoming issue of *Tourism in Marine Environments* (Vol. **4**(2) due in December 2007; www.cognizant-communication.com). This special issue on polar tourism contains eight empirical research papers on Antarctic tourism. Together, the collection of authors and reviewers give this special issue a breadth across the Antarctic tourism research community not seen before (or at least not since the 1994 *Annals of Tourism Research,* **21**(2), special issue).

On a specific study note, I am involved with a research project looking to examine the notion of ambassadorship for the Antarctic wilderness amongst the general public on a global scale. This work is in its pilot phase. The team of researchers located in France, the Netherlands, the U.S.A., and Canada are preparing to examine modifications needed with the survey prior to full implementation. This type of critical social science, while not specifically tourism focused, targets an issue at the heart of the tourism industry's justification for their activities – that of ambassadorship. Considering the huge population who will never visit "the ice", the research team felt it was important to examine what individuals from this group thought about the continent and its protection.

Finally, another important initiative that many Canadian Antarctic tourism researchers are involved with is the SHARE network (Social sciences and Humanities Antarctic Research Exchange) (*CARN Newsletter,* Vol. 23, May 2007, p. 14 and www.share-antarctica.org). While more geographically focused on the Antarctic, but less subject focused on tourism, SHARE provides much the same opportunity as the IPTRN and is also now up and running.

Regardless of the venue (officially linked to the IPY or otherwise), this is now a vibrant and animated time for Antarctic tourism researchers in Canada. There are many different research avenues being brought forward that better connect both the academic and operator components of the industry and field of study in our ever changing world.

Patrick Maher (maherp@unbc.ca) is an assistant professor in the Outdoor Recreation and Tourism Management Program at the University of Northern British Columbia, Prince George, B.C. Portions of his doctoral work in Antarctica were reported on in *CARN Newsletter,* Vol. 18, May 2004, pp. 10–11.

News in Brief

A sad conclusion to the news items we ran in the May 2005 issue (p. 17): the MS *Explorer,* the ice-strengthened, double-hulled ship used by **G.A.P. Adventures,** a Toronto-based adventure tourism company ship, was holed, probably by ice, and sank at 19:00 GMT on Friday, 23 November 2007. The accident took place at 62°24′S, 57°16′W, when the Liberian-registered vessel was in Bransfield Strait, between the South Shetlands Islands and the northern tip of the Antarctic Peninsula. The ship's complement of 100 tourists, 12 of whom were Canadians, and 54 crew members, on a "Spirit of Shackleton" tour, all survived. After several hours in lifeboats in subfreezing temperatures they were picked up by the Norwegian MS *Nordnorge.* The survivors were transferred to King George Island before being flown to Punta Arenas. Readers may be interested to note that at the last Antarctic Treaty Consultative Meeting, in New Delhi in May 2006, to which no Canadian representative was sent, the United Kingdom presented a paper with proposals to tighten the contingency plans of cruise ships. This included a recommendation that cruise ships 'pair' with other nearby ships, in order that response vessels would be within a reasonable sailing distance. This was not adopted because of concerns about the impact on the cruise industry.■

The 3rd International Conference on Polar and Arctic Microbiology will be held in Banff, Alberta, 11–15 May 2008 (www.polaralpinemicrobiology.com). The meeting will include sessions addressing marine and terrestrial ecological processes at low temperatures, genomics and cold-adaptation mechanisms, climate effects, cold-environment mycology, biodegradation, subglacial microbes, and cryobiology, among others. **Julia Foght,** University of Alberta, is a co-chair and other Canadians involved are: **Randy Currah,** University of Alberta; **Lyle Whyte,** McGill University; **Warwick Vincent,** Laval University; and **Charles Greer,** National Research Council Canada. Selected reviewed papers will be published in a special issue of the *Canadian Journal of Microbiology.*■

CCAR members are sometimes approached by representatives of Antarctic tourism companies asking about experts who might join them as lecturers. If any readers want their names put forward they should provide a CV and an indication of the subjects on which they would like to lecture to Simon Ommanney, the Secretary (simon.ommanney @sympatico. ca).■

Following a meeting in Stockholm at the end of September, 2007, the IPY International Youth Steering Committee (IYSC) and the Association of Polar Early Career Scientists (APECS) merged under a new structure keeping the name 'APECS'. It aims to bring together young researchers and early career scientists with an interest in the polar regions and the cryosphere from around the world (http://arcticportal.org/apecs/).■

Further to previous articles in the *CARN Newsletter* about the Argo program (Vol. 15, 2002, p. 1, 3–4; Vol. 22, 2006, pp. 14–15), **Howard Freeland,** Institute of Ocean Sciences, Sidney, B.C., reports that this year the target array of 3000 floats was finally achieved. For further information see www-argo.ucsd.edu.■

The SCAR Subglacial Antarctic Lake Environments (SALE) team has announced the launch of its new and improved web site (http://scarsale.tamu.edu/).■

Professor **Luke Copland** in the Department of Geography, University of Ottawa, is offering a course in Antarctic Studies (GEG3300). To our knowledge, this is the only such course given at any Canadian university. The course will provide a broad introduction to Antarctica and the major scientific and human issues associated with that continent. How Antarctica influences the Earth through its impact on global ocean currents, sea levels and climate will be discussed, as well as subjects such as subglacial lakes, the ozone hole, life in extreme environments, mass balance and ice flow and the geological history. Antarctic exploration over the last century or so, including the 'Race to the South Pole', will be outlined. There will also be discussion of the Antarctic Treaty System and the legal framework under which Antarctica operates. Antarctica provides a unique example of international collaboration, being the only landmass in the world which is not 'owned' as such by any country. A number of local scientists will be contributing their expertise: **Christian Zdanowicz** and **Roy Koerner** of the Geological Survey of Canada; **Kathy Conlan** of the Canadian Museum of Nature; and **Toni Lewkowicz** of the Department of Geography, University of Ottawa.■

The current approach to the challenge of data management for the International Polar Year is through an informal global partnership of data centers, archives, and networks working to ensure proper stewardship of IPY and related data. This partnership is called the IPY Data and Information Service (IPYDIS) and a new web site, discussion forum, and help desk have been established at http://ipydis.org to help coordinate the effort. On the Canadian side, **Scott Tomlinson** is the federal data management coordinator. He can be reached through http://ipy-api.gc.ca/ipcn/index_e.html.■

CCAR/CCRA Members and Advisers

CARN Newsletter

Editor: C. Simon L. Ommanney
Please send contributions and correspondence to:
C. Simon L. Ommanney
Editor, CARN Newsletter
Address at left.

Canadian Polar Commission
Suite 1710, 360 Albert Street
Ottawa, Ontario K1R 7X7
Tel.: (613) 943-8605
Fax: (613) 943-8607
mail@polarcom.gc.ca
www.polarcom.gc.ca