Themes Proposed by the United Kingdom IPY National Committee

A) Generic Observation Theme.

Understanding the slow processes of change near the poles is made difficult by a scarcity of measurements. Mass exchanges with global implications, driven by polar processes, are poorly known today, and determining the existence and causes of change is difficult. With its sharp focus on a single year, IPY provides an opportunity to concentrate and amplify international logistic capability with unusual effectiveness to provide a temporal baseline - a snapshot - of these fluxes. These capabilities include ground and airborne survey, marine survey, particularly from ice strengthened or ice breaking vessels, and satellite survey. IPY will have greatest, long-term impact by identifying a limited number of baseline fluxes, that are both highly uncertain and whose change as far as we know today may be of widest impact, and which may be illuminated by an usual concentration of resources. These foci should be promptly established, so as to allow national, logistic and space agencies the greatest opportunity to plan the joint deployment of resources, and to allow longer term planning beyond 2008 that take advantages of the IPY baseline measurements.

B) Effects of climate change and anthropogenic perturbation in polar regions on ecosystem processes and risks from invasive species

Polar regions are experiencing the most rapid rates of environmental change worldwide, affecting biology at all levels from cells, through organisms and communities, to ecosystems and the entire life support system of the planet. These regions are characterised by chronically low temperatures and restricted water availability and are thus extremely susceptible to the effects of environmental perturbation, because relatively small changes represent biologically extreme events that can have disproportionately large effects. Simultaneously, the physical consequence of changing climate, through providing greater access to pristine habitats, combined with increased biological exploitation and other anthropogenic activities, raises the spectre of biological invasions into polar areas, with unknown effects on ecosystem processes and stability, both terrestrial and marine. This theme will address the interrelationships between changing climate, ecosystem function and the risks from invasive species through three project areas:

1. *Evolution of current patterns of polar diversity,* focused on international collaborative biogeographical and biodiversity surveys across a wide geographical range including both polar regions, combined with modern molecular taxonomic techniques, and linked with palaeobiogeographic reconstruction through geological and glaciological modeling.
2. *Comparison of adaptation and evolutionary rates across wide environmental gradients,* by relating geographical isolation to local adaptation and molecular evolutionary rates, metapopulation structure and evolutionary processes, including the description of 'climate envelopes'.
3. *Quantification of risks associated with alien invasions,* involving ecophysiological determination of environmental tolerance patterns of indigenous and potentially invasive species, and incorporating modeling techniques to develop a 'predictive index' of likely successful invaders.

(C) WAIS instability.

The possibility that the West Antarctic Ice Sheet (WAIS) may be unstable to small perturbations has from the 1970's motivated field observations and theoretical investigations. In the past decade, however, a wealth of new data, mainly from satellites, has shown that thinning is occurring in the portion of WAIS drained by Pine Island and Thwaites Glacier basins, which alone contains 0.8 m of sea level equivalent. The thinning is is strongest near the coast and spatially coherent throughout the sector, suggesting that it is the result of changes occurring at the seaward margins. This thinning is the largest change taking place today in the grounded ice of Antarctica. However, the past concentration of research in the Ross and Ronne-Filchner Ice Shelf sectors, and the Antarctic Peninsula, has left the Pine Island and Thwaites Glacier basins as the least visited part of WAIS. In consequence, our ability to tie down the causes, or predict the further evolution of the thinning, is limited by an absence of ground-based observations. Information essential to the detailed modelling of these basins is missing: the bed topography, its nature, the temperature profile, and the detail of accumulation variability are all missing. To large extent, detailed geophysical investigation of these basins depends on the pooling of international logistics (particularly fuel) that would provide safe and repeated access. IPY provides a clear opportunity to provide the international, logistic infrastructure needed to investigate what is today the most dynamic part of the ice sheet.

D) Humanities and Social Sciences Contribution to IPY 2007

Indigenous Social Science Themes:
Human Dimension of Climate Impact

- This has been a significant area of research in the Arctic social sciences for some years in relation to the IPCC. e.g. focus of American ARCUS 2003 conference, several major studies and publications. There is substantial value in developing this theme for IPY. Programmes such as SEARCH, ACIA and ICARP II could provide an appropriate mechanism as they have given considerable thought to bringing the Human Dimension to climate Impact studies in the Arctic.

This must be included in our choice of themes, but we also want to think ahead to the state of play in 2007 and what new issues lie ahead.

Viability and Forms of Human Settlement

- For several years, Arctic nations have collaborated on a study of living conditions in Arctic indigenous societies to produce for the first time a circumpolar snapshot. The international project has been spearheaded by Prof. Gerard Duhaime in Canada.

Citizenship, State-Building, and Security

- As states evolve in strikingly different political contexts, different approaches to state sovereignty will become increasingly important in defining security in both polar regions. Competing views and approaches to self-determination, resource sharing (incl. oil and gas), and governance in the Arctic may well shape what the British government's policy options.
- Citizenship can also be studied at the micro level where the transmission of values between successive generations and family relations constitute a crisis. Whether the future direction of these peoples is "first world" or "third world" has serious implications for the public's perception that the Arctic is a special region where scientists and local peoples can work collaboratively to understand global futures.

The Legacy of the Sciences: Humanistic Themes for IPY Science and Governance

- The recent attention to the human dimension of Arctic science has shown that the relationship between science and indigenous knowledge is a moving target because northern/indigenous aspirations have rapidly changed. This points towards a broader study of the relationships between science and international governance.
- Governance pertains both to political science, for example, the structure of the Arctic Council, where Britain and other circumpolar nations have significant interests. Governance also shines the light on the natural sciences as instruments of understanding: why scientific evidence is compelling, how it is received by policymakers etc.

The History and Philosophy of the (Polar/Field) Sciences

- This is an excellent opportunity to reflect on the historical legacy of the four IPYs. No other internationally coordinated scientific efforts span the history of the modern field sciences from the nineteenth century to the present. What is the significance of this unique history of scientific research and what does it tell us about science in the polar regions?
- Databases and collections have been the most important way of creating a synthetic understanding of the polar regions. IPY presents an opportunity to encourage current international efforts to understand biodiversity in the polar context.
- Unlike the social sciences, the humanities have no single institution or learned society dedicated to Arctic research. Nevertheless there is a considerable research expertise in the UK working at a high international standard on the history and philosophy of the field sciences. Overlooking this as a contribution to IPY would be to miss an area of research that goes to the heart of IPY.

The Fine Arts and the Sciences

- The fine arts, broadly construed, have been playing a very important role in communicating the polar regions, and even the world of scientific practice, to national and international audiences. It makes sense that artists and writers play a significant role in IPY.

E) Biogeochemistry of the Southern Oceans

The Southern Oceans are a major region for the air-sea exchange of carbon dioxide circulating naturally in the global system, as well as being a very large sink region for man-made CO_2. However, although most models and the limited field observations that exist agree that the sign of the net flux of natural carbon dioxide is into the Southern Oceans, there are significant discrepancies over the magnitude of the sink, both between the various models (one even has the region as a source) and fluxes calculated from the measured concentration fields. Part of the uncertainty is due to the ocean circulation south of the Circumpolar Current involving both the formation of polar bottom waters and upwelling of deep waters formed from high latitudes in the northern hemisphere. In the case of man-made carbon dioxide there are very substantial discrepancies between the models as to the size of the carbon uptake. The situation is made worse by the relative lack of field observations of CO_2 in the region, against which the various models can be tested and tuned. This comes about as a result of the remoteness of the Southern Oceans and its rough weather conditions, a situation which leads to an extreme paucity of field data in wintertime. The situation for other biogeochemically important gases such as dimethyl sulphide and organo-halogens is at least as bad as that for carbon dioxide. In order to address these problems a concerted campaign of field measurements of trace gases and the physical parameters are needed to assess air-sea fluxes, as well as identifying the

formation and return path of deep waters are needed. The field work should be accompanied by a focussed modelling effort. The IPY provides an excellent opportunity for such an exercise.

F) A study of the role of the High Latitude Oceans in the Global Water Cycle.

In view of the exponential increase of water vapour pressure with temperature, it is to be expected that the present extreme warmth of the Earth should be accompanied by an acceleration of the global water cycle and the large-scale changes in ocean salinity that have been observed over recent decades suggest that the Ocean may already be registering such a change. As large reservoirs and sources of ice and freshwater, the high-latitude oceans of both Hemispheres are important components of the Global Water Cycle, and in polar and subpolar seas, the main components of the freshwater budgets have either been observed to change or are predicted to change substantially over the next few decades.

It is for this reason that 'the role of the (bi)polar oceans in the Global Water Cycle' is of an appropriate scale and importance to drive a global investigation in IPY-4 with the broadest possible range of involvement by the scientific community. In the case of the Arctic alone, its study will involve changes in the windfield, in the storm climate, in circum-arctic precipitation and riverflow, in the horizontal and vertical ocean circulation, in the atmospheric moisture flux, in sea-ice extent, thickness and distribution, in the factors controlling the melt-season, in oceanic exchanges with subarctic seas, in the changing mass balance of the Greenland ice-cap, in the ice and freshwater flux to the N. Atlantic and hence in influences on the Meridional Overturning Circulation (MOC or ocean 'conveyor').

The research to be conducted remains to be decided but is likely to take place in three phases: 1) a spinup phase in which long-term records appropriate to our understanding of the ocean-atmosphere-cryosphere system are re-examined to determine the component parts of the Global Water Cycle and their changes with time thus far; in which models are developed that can take account of such changes and their likely forcings and impacts; and in which equipment necessary to the intensive observing phase can be developed: 2) an intensive bipolar observing phase in which all significant components of the water cycle at high latitudes are, for the first time, measured at the same time and assimilated into predictive models, and 3) a spindown phase in which a key subset of variables descriptive of the Water Cycle at high latitudes are monitored as a check on these predictions and during which, at appropriate time-intervals, the legacy of the IPY may be maximised by making systematic repeat measurements of substantial parts of the Water Cycle to develop an understanding of its socio-economic and ecological impacts, as well as to check on what might be termed 'the unforeseen'. Bipolarity of research will be a key. Though Arctic and Antarctic Seas have characteristics and processes in common, their ventilation, circulation, deep-water formation and mode of influence on the global conveyor are quite different. And although annular modes dominate atmospheric variability around both poles, their time dependence appears to be uncorrelated.

Thus scientific involvement in the proposed theme is likely to be both broadly-based and bi-polar, while the socio-economic importance of a global change in the Water Cycle could scarcely be higher. The theme of the (bi)polar ocean in the Global Water Cycle has accordingly been strongly endorsed by a range of international bodies such as AOSB, ASOF, WCRP, CLIVAR, CLIC and iANZONE as well as by a number of national Committees charged with IPY planning.