

news from the



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In This Issue: ASOF plans. . . News from the Arctic Paleo-river Discharge (APARD) Program. . . Future Directions for the International Arctic Polynya Program. . . Information Pertaining to the Arctic Science Summit Week and AOSB Meeting

Developing Plans for an Arctic-SubArctic Ocean Flux Array (ASOF)

Bob Dickson, CEFAS, Lowestoft, UK

(1) *Background.* In May 1999, the AOSB announced plans to study the two-way oceanic exchanges that link the Arctic Ocean with subarctic seas¹. The rationale is bound up with the fact that most projections of greenhouse gas induced climate change anticipate a weakening of the thermohaline circulation (THC) in the North Atlantic in response to increased freshening and warming in the subpolar seas²⁻⁴. Since the overflow and descent of cold, dense waters across the Greenland-Scotland Ridge is a principal means by which the deep ocean is ventilated and renewed, the suggestion is that a reduction in upper-ocean density at high northern latitudes will weaken the THC.

Unfortunately, our models do not yet deal adequately with many of the mechanisms believed to control the THC, and our observations cannot yet supply many of the numbers they need. For example our present observations of this large scale overturning circulation (in the North Atlantic or anywhere else) are insufficient to detect whether or not it is changing; we have *no* measurements of the freshwater flux between the Arctic Ocean and Atlantic by either of its two main pathways; we have new measurements (from the EC VEINS project) of the heat and salt flux to the Arctic Ocean but not yet of its variability on any scale; we have a growing knowledge of the long-term variability of dense overflows which “drive” the THC but only embryonic ideas as to their causes, etc. Understandably then, we would take the view that these key mechanisms and processes are too crudely represented in the present generation of climate models.

News from the AOSB is issued by the Arctic Ocean Sciences board (AOSB) and reports on various subjects for the information of Arctic Ocean research scientists. To obtain additional copies of this newsletter, to suggest subjects for future newsletters or to obtain further information from the Board, please contact the AOSB Staff Group, c/o Directorate for Geosciences, National Science Foundation, 4201 Wilson Boulevard, Room 1070, Arlington, Virginia 22230, USA. Telephone: (703) 292-7856 or on the web at www.aosb.org.

Palaeoclimate records, however, show that massive and abrupt climate change has occurred in the Northern Hemisphere, especially during and just after the last Ice Age⁵⁻⁸, with THC change as the most plausible driver, and both paleo-climate records and models suggest that the changes in the strength of the THC may occur rapidly, in a few decades. Further, in our admittedly-short modern records of ocean variability, we have growing evidence that hydrographic changes of decadal scale in the Arctic and subarctic seas are able to feed south across the deep northern overflows to cause hydrographic changes in the deep and abyssal layers of the Labrador Sea. These variations are large and long-sustained—e.g. the freshening of both dense overflows by between 0.01 and 0.02 per decade for the past 3.5 decades—though we don't yet know enough about process to determine their climatic significance.

The high northern latitudes and the ocean fluxes that connect them to adjacent seas are plainly not the only constituent parts of this problem. The THC is driven globally by upwelling, downwelling and a strong component of upper-ocean wind-forcing, and fluctuations in any one of these components might affect the strength of the THC [see, for example, Toggweiler and Samuels⁹ for the role of the Southern Ocean windfield, or Latif et al¹⁰ for the role of the tropics in re-stabilising the THC under greenhouse warming conditions; see also ref 11]. Nonetheless buoyancy loss in the northern high latitudes and the factors that control it are still of a fundamental importance, are areas of continuing ignorance and are becoming tractable by modern observing systems. These thermohaline controls and linkages, then, form the research focus of ASOF.

(2) *the evolution of ASOF.* In the past year we have made three steps towards constructing a science plan for ASOF. On 6 April 2000 in Cambridge UK, as a joint initiative of the Arctic Ocean Science Board and the International Arctic Science Committee, a discussion meeting on the Sustained Monitoring of Arctic Fluxes was held during Arctic Science Summit Week, with three main objectives. First, to discuss the palaeo- and modelling evidence that THC slowdown or shutdown has happened in the past and is likely to recur in the future. Second, to begin to define the system of critical measurements that will be needed to understand the role of the high-latitude oceans in decadal to centennial climate variability. And third, to discuss ways of achieving the coordinated long-term stamina in our funding that we will need if we are to implement such a system across all the main gateways to/from the Arctic Ocean over a period of a decade or more.

The scientific planning of ASOF was later advanced by means of a second discussion meeting and workshop, held at the Norsk Polarinstitut, Tromsø on 21-24 September 2000, in conjunction with the H. U. Sverdrup Symposium. Whereas the original meeting had focused on the fundamental questions “Has THC shutdown happened before?” and “Are we right to assume it can recur?” the Tromsø workshop had the aim of providing a more complete description of the required observing system, with preliminary costs, and with some results in support (where these exist).

The design of an ASOF array was further refined at a National Academy of Sciences Workshop on *Abrupt Climate Change: Science and Public Policy*, held at Lamont Doherty Earth Observatory, Palisades NY, on October 30-31 2000. Throughout this evolution, discussion has been guided by a sequence of so-called “Strawmen” circulated in advance of planned meetings and intended to provide a concise, modern and expert view of the issues discussed. The third and last of these Strawmen, describing the present state and rationale for ASOF can be found on the SEARCH and NPI websites [<http://www.psc.apl.washington.edu/search/ASOF> and <http://www.npolar.no/asof>].

(3) *Present state of ASOF planning.* Since then, with the active encouragement of the NSF, NOAA, NPI, and the University of Washington’s SEARCH* Program (in many ways the parent body of ASOF), plans have advanced to the point of designing a prototype array (Figure 1) and establishing an International Scientific Steering Group (ISSG) to carry the concept through to implementation. The basic aims have not changed. The intention is still to establish a coordinated, circum-Arctic system of ocean flux measurements with decadal ‘stamina’ to cover all of the gateways that connect the Arctic Ocean with subarctic seas. These space-time requirements are easily justified. Studies by the Seattle Group that motivated the SEARCH program provide clear evidence that recent changes in the marine climate of the Arctic Ocean are decadal and pan-arctic in scale and—at least in part—reflect a changing balance between Atlantic and Pacific influences. And coupled with the fact that the most advanced models now suggest that ocean fluxes through different Arctic gateways may be linked in their time-dependence¹², it makes sense to make these measurements at the same time [*Study of Environmental Arctic Change*].

Figure 1
Configuration of the Prototype ASOF Array

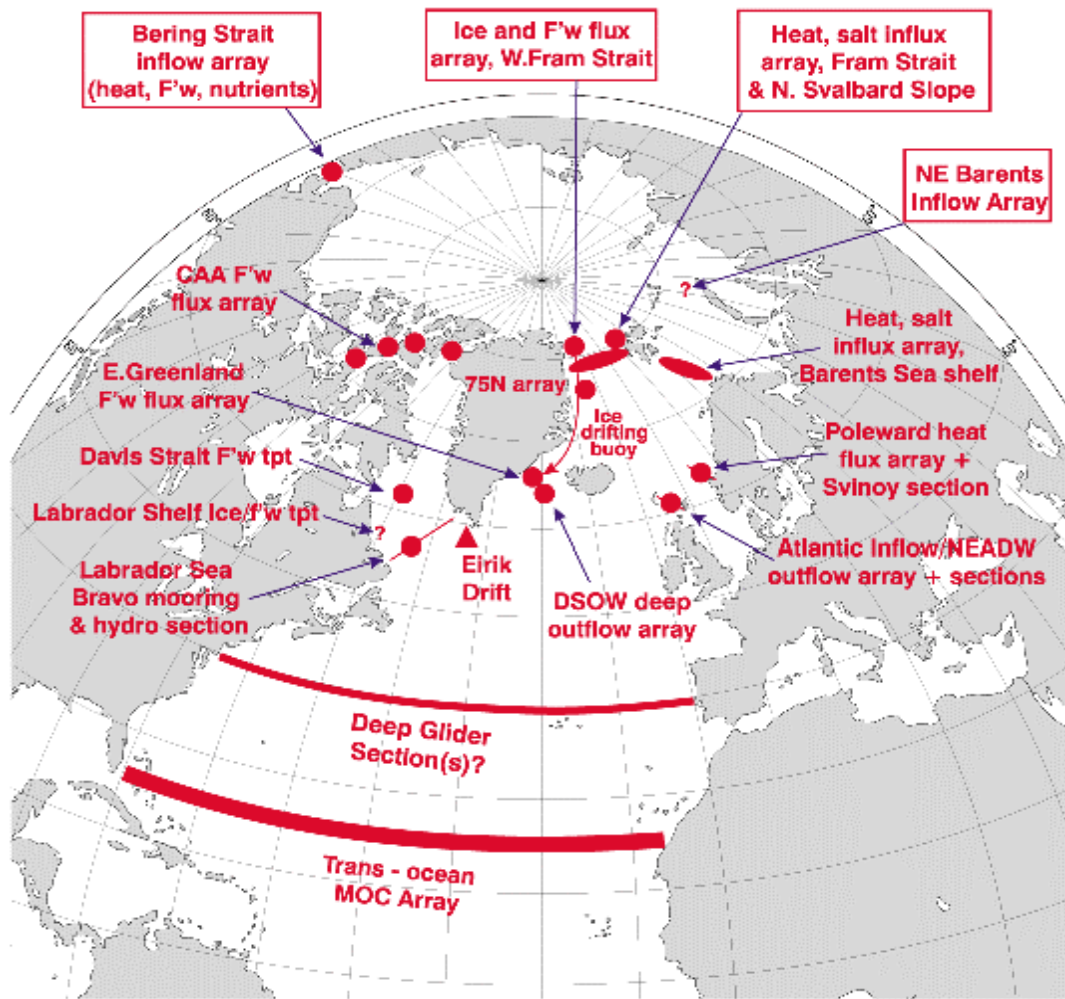


Figure 1. Configuration ASOF Array of prototype

We cannot entirely restrict our attention to “Arctic gateways” however. In a program concerned with the slowdown or shutdown of the THC, some part of our observing system must be directed at measuring the rate of the meridional overturning circulation of the North Atlantic south of the Greenland-Scotland Ridge. Thus the proposed ASOF observing system extends south to 25°N (see Figure 1). It would be myopic also to ignore the Labrador Sea as the site through which all the deep and bottom waters that “drive” the THC must pass, and we devote a considerable observing effort to that site. At least initially, the appropriate emphasis in making our long observational series is seen to lie in “keeping pace with” change, rather than its prediction, while generating the data sets and time-series needed to develop the predictive skill of climate models.

The ASOF ISSG will aim to get most of this array into the ocean by the end of 2003 and four factors suggest this is possible. First, certain of the key measurements are already underway. The transport through the Bering Strait has been estimated for decades¹³ and measured since 1990^{14,15}; the core of the Denmark Strait overflow has been measured with gaps since 1986. Second, in its initial form, the ASOF ISSG is strong in the practical business of maintaining arrays of equipment in these challenging waters. Third, almost all of the techniques needed to make the necessary measurements now seem available or are in prospect.

The development at Bedford Institute of Oceanography of the Watson compass for measuring flow directions close to the north magnetic pole; the emergence of a range of cheap profiling CTD systems capable of sub-ice hydrography; the successful trials of sea-glider systems in the past summer giving the prospect of enriching our sparse moored arrays at realistic cost, mean that this is possibly the first time that much of ASOF might be achieved. And fourth, several recent initiatives give hope of achieving the coordination and stamina of funding that will be vital to implementing a program with the scope and duration that is needed here.

One such is the recent bi-lateral *UK-Norway Initiative on Abrupt Climate Change* proposed to address this issue by the two Prime Ministers in 1998 which has been developed subsequently into a thematic programme by the UK Natural Environment Research Council and into the NOClim programme by the Norwegian Research Council [<http://www.nerc.ac.uk/funding/thematics/thc/ABRUPTFINAL.htm>]. The ease of achieving the required intercontinental spread of funding for ASOF could be greatly helped when an implementing arrangement for NSF-EC co-operation on a range of scientific research topics comes into force. The list of topics, including ASOF, has been agreed and we are told that signing is likely in the next few months.

(4) *Next steps.* We now know the structure of the ASOF-ISSG. Though its membership covers the full geographical spread of the array, we intend to organise the SSG under two Deputy Chairs—Jens Meincke of the University of Hamburg as DC (E) and Peter Rhines of the University of Washington as DC (W)—to permit the western and eastern groups of the SSG to meet with greater flexibility and greater frequency than could the whole group. The ASOF Chair and two Deputy Chairs will meet in Iqaluit during Arctic Science Summit Week in April 2001 to plan the mix of design studies and equipment trials and that will form the business of the full Group until implementation, to progress the ASOF Science Plan including links to national programmes, to report progress to ASSW participants on Project Day (Sunday 22 April); to debate means of international co-ordination in both science and funding; and to receive the collective advice of Arctic operators on unresolved issues. It is planned that once per year in the fall, the full ISSG will meet, beginning in fall 2001 in Washington DC and continuing in (probably) Hamburg in fall 2002, probably as a Euroconference.

The initial discussion phase is all but ended. The work to implementation is beginning. Progress can be tracked on SEARCH, Norsk Polarinstitut, and AOSB web sites.

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(5). References:

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Figure 1. Distribution of the observing sites that make up the prototype ASOF Array. The justification for each is described in the Strawman-3 document on the websites of the U. Washington SEARCH Program and the Norsk Polarinstittutt, Tromso.

Arctic Paleo-River Discharge (APARD) - Report on 2000 activities -

Ruediger Stein, Alfred Wegener Institute, Bremerhaven, Germany

In 1996, the "Arctic Ocean Sciences Board" initiated a new multidisciplinary and international research program on river discharge and its change through time ("Arctic Paleo-River Discharge, APARD"). The APARD Science Plan was published in 1998 (Stein 1998). During the following years, a large number of APARD-related research activities were performed in the western as well as eastern Arctic continental margin and a huge amount of new data on circum Arctic river discharge were obtained (see APARD Newsletters 1 to 4; <http://www.awi-bremerhaven.de/GEO/Arctic/APARD.html>). In the last issue of the *International Journal of Earth Sciences* (Vol. 89/3), new data and an overview of the present knowledge of research on circum Arctic river discharge and its change through geological times has been published (Stein, R. (Ed.), 2000).

Projects and programs

In 2000, new projects and programs in which the Arctic river discharge is a major component, have been developed.

*** Siberian River Run-off (SIRRO): The Nature of Continental Run-Off from the Siberian Rivers and its Behavior in the Kara Sea Area**

(Coordinators: Prof. Dr. Dieter Fütterer; Email: dfuetterer@awi-bremerhaven.de;
Acad. Prof. Dr. Eric Galimov; Email: galimov@geokhi.msk.su)

The overall goal of this Russian-German research project is the understanding of biological, geochemical and geological processes related to the freshwater and sediment input by the Siberian rivers Ob and Yenisei and its impact on the present and past environments of the inner Kara Sea.

The scientific program covers a wide range of objectives:

- (1) to characterize the supply of the rivers Ob and Yenisei with respect to their dissolved and suspension load, to identify processes modifying the river supply in the estuaries and the inner shelf sea, and finally to analyse the dispersal and deposition of the river supply in the Kara Sea;
- (2) to study the response of the planktic and benthic biota on variations in the river supply along the salinity gradient from the estuaries to the inner shelf;
- (3) to study the geochemistry of dissolved and particulate organic matter and hydrocarbon gases in the water column and the sediments;
- (4) to study the dispersal and distribution pattern of contaminants;
- (5) to reconstruct temporal and spatial changes in the late Weichselian and Holocene paleoenvironment along transects from the estuaries of the rivers Ob and Yenisei towards the open Kara Sea; and
- (6) to model transport processes and biogeochemical fluxes

* **Western Arctic Shelf Basin Interactions (SBI)**

(Coordinator: Dr. Jackie Grebmeier; Email: jgreb@utkux.utk.edu)

The Western Arctic Shelf Basin Interactions (SBI) project is a multi-year, interdisciplinary program to investigate the impact of global change on physical, biological and geochemical processes over the Chukcki and Beaufort Sea shelf basin region in the Western Arctic Ocean. For further information see <http://utk-biogw.bio.utk.edu/SBI.nsf>

* **Arctic Coastal Dynamics**

(Coordinator: Dr. Volker Rachold; Email: vrachold@awi-potsdam)

The Arctic Coastal Dynamics (ACD) program aims to develop and coordinate a multi-national, multi-disciplinary program of circum-Arctic coastal research to define and apply a classification system for coastal mapping and for assessing the sensitivity and erosion potential of Arctic coasts. Program objectives are:

- A. to develop and apply standard techniques for mapping and measuring erosion and accretion.
- B. to identify and investigate critical processes that affect dynamics of high latitude shorelines.
- C. to develop estimates of erosion rates and sediment production for circum-Arctic coastlines.

Expeditions

In 2000, two major APARD-related expeditions were carried out.

* **Expedition LENA 2000**

Within the framework of the project Laptev Sea 2000, two large expeditions (LENA 98 and LENA 99) were carried out during the last years. In order to continue and to complete the studies, a third expedition (LENA 2000) was carried out in the Lena Delta and the Laptev Sea coastal area from July 28 to August 27, 2000. During this expedition, modern processes and the environmental history of the Lena Delta area have been investigated by a Russian-German team of 20 scientists. The APARD-relevant studies focused on coastal studies along the western Laptev Sea. Approximately 10 coastal sections were investigated to quantify coastal retreat rates, to investigate the shoreface bathymetry and to sample coastal and shallow water bottom sediments. The objective is to quantify the sediment input to the Laptev Sea by coastal erosion.

Russian Expedition Leader: Dr. Mikhail N. Grigoriev (PIY)

German Expedition Leader: Dr. Volker Rachold (AWI Potsdam; vrachold@awi-potsdam)

* **Kara Sea Expedition 2000**

Within the framework of the joint Russian - German project on "The Nature of Continental Run-Off from the Siberian Rivers and its Behavior in the Adjacent Arctic Basin", a third expedition with RV "Akademik Boris Petrov" was carried out in the Ob and Yenisei estuaries and adjacent inner Kara Sea in August-September 2000. Work has been concentrated on a south-north transect from the Yenisei River toward the open Kara Sea between 70°N and 77°N . The participating Russian and German scientists intended to study biological, geochemical and geological processes relevant for the understanding of the freshwater and sediment input by the Siberian rivers Ob and

Yenisei and the impact on the environments of the inner Kara Sea. During the expedition, an extensive sampling program was carried out on a total of 40 stations. The stations for sediment sampling were carefully selected based on profiling results by means of a ELAC Sediment Profiler and a 3.5 kHz Sediment Profiler. Furthermore, the profiling results give detailed information about the seafloor topography and the thickness and structure of the youngest (Holocene?) sediment cover. In addition, one sediment trap was deployed north of the Yenisei Estuary, respectively, to obtain data on the seasonal variation of particle flux during one year.

Russian Expedition Leader: Oleg Stepanets (Vernadsky Institute; stepanet@geokhi.ru)

German Expedition Leader: Ruediger Stein (AWI; rstein@awi-bremerhaven.de)

International Arctic Polynya Programme: New Directions

Jody Deming, Chair, IAPP Scientific Coordinating Group, University of Washington

The International Arctic Polynya Programme (IAPP) was conceived by members of the AOSB in the late 1980s as a means to focus international attention on what were clearly unique but understudied features of open water at Arctic latitudes. Although already known at the time to be important to heat exchange between ocean and atmosphere and to the livelihood of higher organisms, from marine mammals to indigenous peoples of the Arctic, polynyas were poorly understood from either a mechanistic or ecosystem perspective.

The framers of the "terms of reference" for the IAPP recognized the abundance of pressing fundamental questions about polynyas, as well as the rarity of coordinated interdisciplinary studies to tackle them. What physical forces allow a given polynya to form, stay open, close and recur predictably? What biological adaptations allow organisms to take advantage of these temporary openings in the ice? How do the combined forces of ocean, atmosphere and ice link together with chemistry and biology to explain long-term ecosystem dependency on a transient physical feature? And perhaps most importantly, what does the future hold for these necessarily fragile ecosystems in the face of global change, the local effects of which were predicted to appear first and in most amplified manner in the Arctic?

The primary goal of the IAPP to foster interdisciplinary and international studies of Arctic polynyas reached clear fruition in the last decade, with Professor Louis Legendre (at Universiti Laval in Quebec City, Canada, during this time) serving as chair of the Science Coordinating Group. The IAPP plan called for concerted study of three Arctic polynyas – the St. Lawrence Island Polynya (SLIP) in the Bering Sea, the Northeast Water (NEW) Polynya off the northeast coast of Greenland, and the North Water (NOW) Polynya in northern Baffin Bay.

Although the SLIP site has continued to be the subject of numerous disciplinary and interdisciplinary studies over the years, the NEW and NOW sites became the objects of time-intensive, highly coordinated international efforts. Under German and American leadership, the NEW region was occupied for land- and ship-based studies by an international team of more than a hundred investigators from a wide array of disciplines during the summers of 1991-1993. An equivalent field program was undertaken in the NOW region during the years 1997-1999 under Canadian leadership with significant platform support from American and Japanese sources, ultimately achieving remarkable ship-based coverage of the area from March to October.

In both studies, long-term moorings provided continuous data recordings during the entire study period. Although each project was designed uniquely around the specifics of its region, results from the NEW project helped shape the NOW project, with both efforts benefiting from a continuity of concepts, questions and an overlapping subset of investigators. An extensive list of publications has emerged from these studies, including special issues in the *Journal of Geophysical Research* (1995), *Journal of Marine Systems* (1997), and the journals of *Deep-Sea Research* and *Atmosphere-Ocean* (both anticipated 2001). Major general findings include the recognition of direct connections between sea-ice features, water-mass circulation (on seasonal and annual time frames), nutrient inputs and biological responsiveness that help to explain why the NEW polynya supports less overall productivity than the NOW polynya and why the NOW may represent the most biologically productive marine region in the Arctic.

As we move into a new decade of Arctic research, fundamental parameters have changed from the time of inception of the IAPP. Predictions of environmental change in the Arctic have materialized in the form of evidence for significantly reduced ice cover and warmer temperatures in the ocean and atmosphere. Attention has shifted from biological activity in the marginal seas and consequent export of carbon and organisms to lower latitudes (as represented to large degree by SLIP, NEW and NOW) to the potential for both feast (lower organisms dependent on light passing through thinner ice) and famine (higher organisms dependent on stably thick ice) at higher latitudes and in the central Arctic basin.

As incoming chair of the IAPP, I believe that the Science Coordinating Group has an opportunity and obligation to help build upon knowledge gained in the '90s and to foster future research on polynyas that may be influencing various processes at higher latitudes or have more direct connections to changes ongoing in the central Arctic. Significant progress has already been made under Canadian leadership towards establishing the Canadian Arctic Shelf Exchange Study (CASES), which will include study of the Cape Bathurst polynya that forms on the Mackenzie Shelf off the northwestern Canadian coastline. Unlike the NEW and NOW polynyas, the Cape Bathurst polynya is located within the Arctic Ocean, forming part of the circum-Arctic lead-polynya system that stretches over the extensive Arctic continental shelves. It also borders the Chukchi Shelf region that will soon come under intensive investigation under an American program known as Shelf-Basin Interactions (SBI). International coordination between CASES and SBI could yield scientific advancements greater than either program alone will achieve.

The time is also ripe for taking a broader geographic view of Arctic polynyas. Opportunities to merge data bases and resulting analyses from past, ongoing, and future research in polynyas along the European/Russian sectors of the Arctic should not be missed if we are to achieve a pan-Arctic view of the impacts of global change on these open waters that many consider to be critical biological oases as well as significant sites of heat and gas exchange with the atmosphere.

With this goal in mind, an International Polynya Symposium under the auspices of the IAPP is planned for September 2001 in Quebec City, Canada (look for the second announcement coming in March or contact deming@u.washington.edu). This gathering, bringing together polar researchers from all over the world, will provide a unique opportunity to exchange information and identify common and divergent themes across disciplines and between polynyas from both hemispheres. New ideas, plans for future research, and avenues for publishing syntheses of work to date are expected to emerge. In light of a recent decade of remarkably successful research in Arctic polynyas and immediate prospects for the future, I look forward to working with old and new colleagues on the IAPP-SCG to develop and implement a vision for the next decade of polynya research, one that builds upon the last and leads us to an enlightened understanding of what the future holds for life in general north of the Arctic Circle.

ARCTIC SCIENCE SUMMIT WEEK

22-27 April 2001

Iqaluit, Nunavut, Canada

The Arctic Science Summit week is held during April each year. This year it will be held in Iqaluit, Nunavut, Canada. An initiative of IASC, its rationale is to provide a focus for opportunities for co-ordination, collaboration and complementarity in all areas of Arctic science, and to combine science and management meetings to save time and travel. The week comprises a series of meetings of circumarctic science organizations, organised around a joint science day focussed on topical issues of concern to them all. AOSB will hold its 20th meeting on Monday, April 23 and Tuesday, April 24 in the Frobisher Hotel. The meeting is open to members and invited guests. For more information and to view the agenda go to the AOSB web site at www.aosb.org.

On Sunday, April 22, AOSB is hosting an ASSW project day which is designed to bring together all ASSW participants to hear reports from various Arctic projects. Scientists involved in thirteen different Arctic projects will present information about their projects and answer questions. Project Day epitomises the goal of ASSW by bringing together the various Arctic organizations in one room during the course of the day to learn first-hand about Arctic programs. Project Day is open to the public. The agenda for Project Day can also be viewed at the AOSB web site.

Science Day will focus on sustainable development in northern communities. The morning session will deal with terrestrial issues while the afternoon session will focus on sustainable marine resources and climate variability. AOSB will host the afternoon session. The agenda for Science Day will be available shortly on the AOSB web site.

The following circumarctic organizations have indicated an interest in taking part in ASSW:

Arctic Ocean Sciences Board (AOSB)
European Polar Board (EPB)
Forum of Arctic Operators (FARO)
International Arctic Science Committee
Nansen Arctic Drilling (NAD)

Nordic Polar Group
Canadian Polar Commission
Arctic Research Consortium of the US
Polar Research Board
U.S. Arctic Research Commission

For more information go to www.nac.nu.ca/nri/index.htm

The 20th Arctic Ocean Sciences Board Meeting

**22- 27 April 2001
Iqaluit, Nunavut, Canada**

For more information:
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