

**ARCTIC OCEAN SCIENCES BOARD (AOSB)
Twelfth Meeting (AOSB-XII)**

**14-16 January 1993
Seattle, Washington, USA**

OPENING OF THE MEETING

The Chairman, Dr. Eileen Buttle, opened the meeting and welcomed the participants, regretting the absence of representatives from Iceland, Russia and Sweden. The Acting U.S. Representative, Mr. Louis B. Brown, also welcomed the participants to Seattle. The draft agenda was reviewed and approved, with the addition of an item on the joint Canadian-U.S. Arctic Section Programme scheduled for 1994.

THE INTERNATIONAL ARCTIC POLYNIA PROGRAMME (IAPP)

The Chair of the Scientific Coordinating Group (SCG) for the IAPP, Prof. Louis Legendre, presented the Group's report, including the report and recommendations from the International Arctic Polynia Workshop which had been held just prior to the AOSB Meeting. Dr. Legendre reminded the Board that a "glossy" on the IAPP which had been discussed at the previous AOSB Meeting had not yet been published.

The IAPP Workshop had reviewed progress on research in the three polynyas (Northwater, North East Water and the St. Lawrence Island polynya) and in the disciplinary programmes. Then focus shifted to plans for future work, especially for joint studies in the North East Water scheduled for spring of 1993. A series of working groups then addressed specific topics of interest. It was agreed that studies of polynyas should generally be initiated before the polynyas actually open, although this will not be possible for the upcoming NEW programme. Measurements of processes occurring under and above the ice prior to the opening are also considered important.

It was noted that study of polynyas is essential to understand the transfer of biogenic carbon in northern waters. The way the polynyas channel primary production is more important than measurements of the actual rates of such production. The circulation pattern in the polynya is more like a clockwise gyre than a northern inflow - southeastern outflow process. It will be essential to obtain data in the surface layers for future polynya studies.

The formation of ice itself generates heat flux. When polynyas are open, they transfer substantial heat to the atmosphere, but leads actually transfer much more. Thus, the role of polynyas in heat transfer may be much smaller than originally thought. It had been hypothesized that polynyas provide a sink for biogenic carbon to transfer from the atmosphere to the ocean. However, it turns out that polynyas may actually transfer carbon from the bottom to the surface, especially in shallow-water polynyas. In deepwater polynyas, the opposite may be the case, although present data is insufficient to clearly demonstrate these hypotheses.

In response to a question as to whether future polynya research would include sedimentation studies which would seem to be essential for some of the identified objectives, Prof. Legendre reported that there are plans for both moorings with sediment traps for longterm studies and sediment traps for short-term studies. A series of ten short cores was taken last year and sub-bottom profiles have also been made. There is a geology group aboard R/V *Polarstern* to collect such data, although bioturbation is a problem in collecting data on sedimentation.

In shallow-water polynyas (up to fifty meters depth), such as the Laptev Sea, sediments are scavenged by frazil ice which actually picks up sediment at the bottom and carries it into the ice. This process could be very important in the long term to studies of sediment transport and pollution.

The Northwater Polynya Project (NOW)

It was reported that there is virtually no possibility for finding logistic support for NOW research through traditional sources. There is a possibility of a small French vessel being available for such research. This vessel could not break ice, but would be capable of withstanding being frozen in.

The St. Lawrence Island Polynya Project (SLIP)

With respect to the St. Lawrence Island Polynya, it was reported that scientists had earlier underestimated the strength of circulation in the western reaches along the Strait of Anadyr. There is a significant transfer of ice northward in that region, although wind reversal can also reverse the direction of the ice flow. A key question facing researchers is whether the polynya is influencing biological production in the region. It appears from recent research that there is a region of very high productivity and a rich benthic community along the south edge of the polynya which is active very early.

Recent studies have identified a series of important questions which need to be addressed. It appears that an icebreaker, the USCGC *Polar Sea*, is likely to be available for research in the region in 1995, thus permitting winter study of SLIP as well as the retrieval of moorings put in the year before. It is not yet clear when the vessel will be available; the nature of the research that could best be conducted will be determined by the stage of polynya development at the time the vessel is available.

The North East Water Polynya Project (NEW)

Two workshops had been held for planning NEW-93. A scientific team of seventy scientists from many countries was selected. The resulting programme takes into account results of work recently completed, as well as research planned for the Polar Sea, although the demands for shiptime far exceed the time available. The Polarstern plans to follow the IAPP and the Joint Global Ocean Flux Study (JGOFS) guidelines for observations. An extensive land observation programme will also be conducted, mainly where bird, mammal and marine populations are expected to be extensive.

It was noted that a coastal Greenland Current moves northward along the Greenland coast during the polynya, becoming warmer as it moves northward. Additional measurements indicate that this current then turns eastward and then southward, creating an anticyclonic gyre of which the polynya is roughly the western half.

The polynya remains open over a small area in the north over winter which requires study to fully understand processes in this polynya. Nitrates appear to be the limiting factor on biological productivity; the values are so low that high biological productivity cannot be expected. Little information was collected on birds and mammals in 1992, thus scientists are looking forward to the extensive programme planned in this area for 1993.

The start dates of the polynya vary extensively, and the opening is gradual. However, the polynya closes each year in the second/third week of September and does so very quickly. Estimates of ice cover (on which this premise is based) are within about five percent. Some meteorological data is available from an automatic weather station on Krojers Høhne operated by

the Danish Meteorological Institute. In the future, it might be possible to set up portable meteorological stations in the region since other groups such as geological survey teams are also operating in the region.

It was suggested that the tight close-up of the polynya might reflect a response to solar radiation and that the vertical heat flux in the polynya region requires further study. SAR imagery of NEW indicates a regular pattern of reflectivity in the sea surface at roughly five-kilometer intervals; these may in turn indicate the influence of atmospheric gravity waves on the ocean. A similar image of ice in the region shows a clear striation at five kilometer intervals in the ice. In another image north-south striation in clouds above this region at other times can be seen which appears to indicate air-sea-ice interaction.

Board Policy on Polynya Research

The Board reviewed the recommendations from the SCG, the first of which called for broadening of the IAPP to include the Laptev Sea and Franz Josef Archipelago, and Okhotsk Sea polynyas. It was recognized that the IAPP had been set up to develop comparative studies of three scientifically interesting polynyas. It now appears that it is necessary to take into account that only some polynyas can be studied at certain times and only to certain degrees. From the results presented at the IAPP Workshop, it seems that the original categorization is not as applicable as originally thought. The possibility of broadening the scope of the IAPP to address other polynyas and possibly changing its mandate was discussed.

An initial objective of the IAPP was to study the structure and processes of polynyas and their interaction with the broader oceanic, atmospheric and terrestrial regimes. It was recognized at an early stage, however, that economic constraints would require that scientists aggregate their limited resources in this area, especially with respect to logistics.

The Board invited the IAPP to continue to pursue its initial objectives and to continue to promote study of the three polynyas originally identified. It was agreed that the IAPP be given the latitude to broaden its scope to take advantage of opportunities to promote research in new areas. To this end, the Board encouraged the SCG to invite scientists involved in studies of other polynyas to participate in IAPP activities and to inform the SCG of their research interests and results. The Board also invited the SCG, following the field studies in early 1993, to review the mission statement and core programme and determine if they require updating and revision on the basis of the results of the initial field studies.

The Board decided to offer to support the publication of a special edition of the AOSB Newssheet for the IAPP, rather than a glossy for which publication costs could be very high. This Newssheet would be based on the mission statement and the results of the Workshop just completed. The Secretariat will investigate options for the printing of the Newssheet.

It was agreed that the objectives of an IAPP symposium would have to be clearly defined and that the scheduling of the symposium would have to allow for the analysis of collected data and preparation of well-formulated results. Thus, early 1994 would not be practical. It was noted that planning is also being initiated for a Greenland Sea Project (GSP) Symposium. It was suggested that an IAPP Symposium be convened in 1995 back-to-back with the AOSB. **The Board strongly supported the concept of an IAPP Symposium in 1995 but considered that such a Symposium might be most effectively organized as a stand-alone meeting. The Board requested the Scientific Coordinating Group for the IAPP to consider how best to make arrangements for scheduling the Symposium and developing an agenda.**

THE CANADA-U.S. ARCTIC OCEAN SECTION PROGRAMME

The U.S. and Canada are planning a joint Arctic Section Expedition to contribute to the Arctic Climate Systems (ACSYS) Study of the World Climate Research Programme (WCRP). The scientific objectives of the Expedition are to study those aspects of Arctic oceanography bearing on global change. The study will address the circulation and spatial distribution of water masses in the Arctic Ocean. The programme calls for crossing the Arctic during 1994 from the Bering Strait. The two vessels are the USCGC *Polar Sea* and the CCGS *Louis S. St. Laurent*. There would be from 26-32 science berths available on each vessel. Drs. Knut Aagaard and Eddy Carmack are taking the scientific lead in the two countries.

The *St. Laurent* will be converted to a fully capable oceanographic vessel before its departure from Halifax. It also will be available for scientific work from Halifax to the Panama Canal to Vancouver to Adak and then in the Bering Sea to the Strait. The dates of the transect will be July-August 1994 (sixty days).

RAIOACTIVITY IN THE ARCTIC

It was reported that the results of the recently-completed Russian-Norwegian cruise in the Kara Sea indicated that Cesium 137 levels were, in fact, lower than those measured during the Russian study of 1982. Thus there appear to have been no significant increases in oceanic radioactivity in the Kara Sea over this ten-year period. A Polish team had worked in Novaya Zemlya at about the same time. Radioactivity levels in Novaya Zemlya were essentially similar to previous background level measurements. However, measurements at higher latitudes in Franz Josef Land showed much higher concentrations. It was noted that another Russian vessel operated in the same area at about the same time, but the data are not yet available.

It was acknowledged that these results are puzzling, since many scientists had expected that the water column would demonstrate much higher levels of CS-137. A paper presented at the IAPP Workshop noted that observations off the Lena River had shown high levels of radioactivity, apparently arising from uranium mining and processing. It was noted that longer-term monitoring of radioactivity in Arctic seas is expected to provide input to and is likely to become a feature of the Arctic Monitoring and Assessment Programme (AMAP).

The Board concurred it is essential that AMAP is designed to collect data that can be used by the scientific community to better define Arctic ocean processes. The design of and quality assurance for the AMAP system should be guided by the scientific community. The Board encouraged the further development of national AMAP programmes. The Board decided to invite AMAP to be represented at the next meeting in order to develop more effective interaction between the AMAP and the AOSB. The Board agreed that it is important to identify what science can contribute to the AMAP programme and, to this end, stressed the need to promote appropriate input from the research community into AMAP, both with regard to scientific requirements and scientific guidance regarding the design of the system.

U.S. Programme on Radioactivity in the Arctic

Dr. Leonard Johnson reported that a new programme had been established in the United States to study the disposition and fates of radionuclides introduced into the Arctic Ocean. This programme is funded at \$10 million. A major objective will be to develop databases for the Kara, Barents and Beaufort Seas to define the present levels of radionuclides in these environments, including ocean waters, biomass, river plumes and sediments.

The programme is intended to, among other things, determine the levels of nuclear

wastes introduced into these waters; assess the contaminant levels in relation to background levels; and identify and assess any threats that such radionuclides might pose for Arctic ecosystems.

POLISH-RUSSIAN COOPERATION IN ARCTIC RESEARCH

Dr. Jan Marcin Weslawski reported that three institutes of the Polish Academy of Sciences are playing major roles in Arctic research in cooperation with three Polish universities. These institutes cooperate with their Russian counterparts through agreements with the Murmansk Institute; the Zoological and Botanical Institutes of the Academy; the Institutes for Oceanology and Geography of the Academy; the AARI in St. Petersburg; the Institute of Hydrometeorology; and the Institute for Nature Protection in Moscow. This cooperation has resulted in three joint Norwegian-Polish-Russian expeditions to Franz Josef Land.

Polish scientists have prepared a directory of Russian scientists engaged in Arctic research which we would be pleased to distribute to AOSB members. The well-known map which identifies zones of pollution, including nuclear pollution, in the Kara and Barents Sea is intended to be updated for printing in April/May 1994. Additional information recently obtained from archives suggests that as many as 25 Soviet nuclear submarines could be lying on the seabottom in the Kara Sea.

NANSEN CENTENNIAL ARCTIC PROGRAMME (NCAP)

The former six scientific councils in Norway have now been combined into the Norwegian Research Council under whose aegis the Scientific Expedition is being organized. It is recognized that some knowledge is available regarding the surface and surface layers of the Arctic Ocean, but that very little is known about the deep water. The NCAP has a major objective with four specific subprogrammes.

The expedition will involve a drifting ship with satellite camps. The ship will have 25 scientific berths, with staff to be rotated every two or three months. It is specified that the ship should be able to carry about two years of fuel; additional fuel may be available through refueling by other vessels which may be in the area. **Hovercraft will** be used to transport staff and equipment between the ship and satellite camps. Tenders for the ship must be submitted by 1 March 1993. A Nansen Centennial Symposium will also be convened on 21-25 June 1993 in Slostrand-Bergen Norway.

EUROPEAN COMMITTEE ON OCEAN AND POLAR SCIENCES (ECOPS)

ECOPS is a joint committee of the Commission of the European Communities (CEC) and the European Science Foundation (ESF). Prof. Gotthilf Hempel is the Chairman. Its mandate is to provide strategy for European science in oceanography and polar research. This will influence both the CEC and national funding agencies in the future. In the short term, ECOPS is aiming to see references to its "Grand Challenges" included in the EC's Fourth Framework Programme.

ECOPS, working through the ESF, has established a series of Euro-research Conferences and symposia on a variety of topics within its mandate. The ESF has agreed to support a formal programme of workshops and symposia on Ice-Sheet Modelling (EISMINT).

THE GREENLAND SEA PROJECT (GSP)

Dr. Jens Meincke reviewed the development of the GSP. The convective system of the Greenland Sea contributes to the "conveyor belt" of ocean circulation and global thermohaline circulation. The primary objectives of the GSP are to determine the nature and extent of this

contribution and to determine how variability in the Greenland Sea system affects this contribution, both qualitatively and quantitatively.

To achieve this objective, field studies were planned to identify and measure the key processes, and modelling studies were planned to develop hypotheses for the circulation of the Greenland Sea and its interaction with the conveyor belt. It had been planned from the outset to conduct two intensive field studies, recognizing that the results of the first would influence the design and planning of the second.

Field work was initiated in 1986 but the first intensive study was undertaken in 1988 and 1989, collecting data in all four seasons. The data bases developed were sufficient to characterize the water masses in all four seasons (temperature, salinity, oxygen, topography) This permitted a determination of the amount of water advected during the 1988-1989 period. The water masses clearly changed over the period of the study, but it became evident that these changes were a result of advection, as well as convection. Moorings were used to measure longer-term variability to enable determination of the advective field. A tomography experiment also provided valuable additional information on the geostrophic field, mean currents, etc.

Stratification, circulation and water masses are the three areas in which the study will focus. The second field phase has begun without having final numbers as to the amount of water advected during 1988-1989. A Princeton model driven by six-hour winds was tried, but had a resolution of only twenty kilometers. Using the Cray computer at Hamburg, an eddy resolving model has been tested with a resolution down to about one kilometer. It has been tried with constant winds; now it is being tried with variable winds using three different schemes--these are based on numerical bases developed by the FRG Meteorological Service.

Basic circulation is, of course, wind-driven; advection is of thermohaline origin. Major field studies were undertaken of air-sea interaction with a focus on determining heat flux and how heat flux is affected by cold-air outbreaks when cold air leaves the ice and travels south over the water. Heat fluxes of 240 watts per square meter were observed during such outbreaks. Since these figures seem very low, it is intended to undertake further experiments to verify this figure.

Winter convection was observed in 1986 and 1987 to extend down to 250-300m; in 1988 to 1200m; and in 1989 to 1600m. ADCP's have also observed a few convective events on smaller scales over short time periods--four events over a two-year period. Vertical velocities were observed to be two-to-four centimeters per second for a few hours only. Chimneys of multiple plumes were also observed to develop on the scale of ten kilometers. The plumes have a time scale of about a day; the chimneys, about ten days.

Some results have been published; other key studies are just now being completed. It is clear that there has been no renewal below 1600 meters in the Greenland Sea. The renewal rate was earlier thought to be on the order of ten years; now it appears that a renewal rate of tens or hundreds of years is more appropriate for the deep water. This, of course, does not affect the conveyor belt since the major input to the belt from the Greenland Sea is at intermediate depths. In summary, the convection is not highly energetic and is focussed at intermediate depths.

The ice programme is concerned with the role of the sea ice in the energetics of the Greenland Sea as a whole and with the specific interactions between the ice and water involved in the convection. It is intended to measure ice volume fluxes into the Greenland Sea by upward-looking sonars and by combining these measurements with SAR observations. South of 75 degrees North, the Odden ice tongue extends into the Greenland Sea on time scales of weeks to months. Convective plumes, it appears, are triggered by this ice tongue.

It is important to learn more about young ice and its cycling in the region; remote sensing should assist in this effort. Frazil ice is theorized to develop into clumps above the tops of plumes, but evidence of their existence is not yet clear. It may be possible to locate plumes by detecting these clump "caps" in the ice overhead. It is also important to measure ice thickness over the region. Since submarines are not available, an autonomous remote vehicle with both upward-looking and side-scan sonars will be deployed in May 1993 from the R/V *Valdivia*. The vehicle is equipped with an inertial navigation system.

Dr. Hans-Jürgen Hirche reported on the European Sub-Polar Ocean Programme (ESOP). ESOP represents those aspects of the GSP for which the Commission for the European Communities has decided to provide substantial new funding to European scientists under their MAST-II (Marine Science and Technology) initiative. The programme is expected to last for three years with a focus in sea ice-ocean interaction. The first part of the programme will support the GSP field study coming up; the second part will involve laboratory work and modelling studies to be conducted through 1995.

Under the GSP, two primary objectives were to improve understanding of both primary production and particle flux in the Greenland Sea. However, it has not yet been possible to develop the time series needed to fully understand the processes. Data is available for winter and summer data, but information is lacking for the fall and spring.

Grazing in the Greenland Sea gyre and the West Spitsbergen Current will be studied in 1993. Large blooms of certain species, especially in late August and September, are used primarily by the microbial loop and then sink to the bottom where recent studies indicate they serve as the basis for an extensive benthic productivity.

Dr. Preben Gudmandsen reviewed the remote sensing aspects of the GSP. By means of passive microwave radiometry, first-year and multi-year ice can be categorized, but at spatial resolutions of about fifty kilometers only and with an accuracy of five-to-ten percent. It may also be done by means of radar at a much finer resolution (a few hundred meters), but so far this process often requires manual analysis of scenes to resolve ambiguities.

To determine the ice extent, passive and active measurements are used at spatial resolutions of 25km (passive microwave) and kilometers (SAR and visual/infrared). To determine how much ice is advected through a region, the area and the velocity is measured so the volume of ice may only be determined by adding information about drought from upward-looking sonar. Southward flow velocities of up to fifty cm/sec have been measured in the drift along the continental shelf break in the Greenland Sea. The ERS-1 SAR has shown a number of features which were not observed with previous sensors. Thus, there are examples of what is believed to be air-sea-ice interaction in areas with ice concentrations of sixty-to-eighty percent and in open ocean areas, the physical mechanisms of the latter not being fully understood.

The ERS-1 SAR has a swath of only 100km. Thus a series of swaths is necessary to cover the Greenland Sea. During the six hours between an ascending and a descending orbit observation, the surface can change significantly due to weather changes and thus a "snapshot" of the entire Greenland Sea is not of great avail (the Canadian Radarsat may alleviate this situation). Application of SAR data is also constrained due to the fixed angle of incidence (23 degrees) and the use of vertical polarization.

Plans for 1993 Field Studies in the Greenland Sea

Dr. Jens Meincke presented a timetable for the second intensive field study. For water mass studies, the R/V *Polarstern* will repeat the standard Greenland Sea section plan. The R/V

Valdivia will conduct field studies in the central gyre beginning in February and will return again to repeat the centers pattern in May/June. The shipboard studies will be augmented by moored arrays.

The meteorological programme (ARKTIS '93) will be conducted by ice drift buoys, land and ice stations, aircraft and related support facilities. The radiosonde programme throughout the region will be upgraded for the period of this work. Process studies of cold air outbreaks will also be conducted. These will involve use of the R/V *Polarstern*, as well as a series of ice stations. Four airplanes are expected to be available as well.

The R/V *Valdivia* and the R/V *Northern Horizon* will tow temperature and conductivity sensors to determine the temperature and salinity structure to about 300m. Acoustic techniques will be used to locate plumes in the core area and will be verified by aerial photography using the BAC 1-11 aircraft of the Defense Research Agency, Farnborough.

The overall planning has been based more on modelling work done in advance rather than in the past. This will be the first winter effort in the Greenland Sea and scientists are optimistic about observing a cold air outbreak. Similarly, the oceanographic work is based on recent time series data. The work in 1993 will also address fresh water inflow, where earlier studies had not considered waters of less than about 34.7 per mil. Standard biology and partial CO₂ will also be measured throughout the cruise. Efforts will also be made to determine the density of frazil ice. The R/V *Oceania* will be working on the Atlantic Ocean side during the 1993 field work. The R/V *James Clark Ross* will not be able to join the 1993 programme because of necessary shipyard work, but will operate in the region in 1994.

The results of GSP field studies are expected to be made available as usual through regularly reviewed scientific literature. A master file will be set up to keep track of these publications and prepare indices as needed. A symposium has long been considered important for the programme, tentatively scheduled for November 1993 in Hamburg, together with an international meeting on Atlantic coastal seas. Many of the results of the work completed have already been presented, at least in preliminary form.

The Board recommended that the Greenland Sea Symposium be postponed until 1994 after the upcoming field studies have been completed. Such rescheduling would assure that the Symposium provides a true wrap-up for the Greenland Sea Project since at least initial results of the second intensive field phase of the GSP could be presented. It was also suggested that the November 1993 dates could be used for a GSP workshop which could also develop firm plans for a Symposium in 1994.

It was pointed out that the Greenland Sea Project had originally been envisaged as a five-year research programme which would be followed by a five-year monitoring programme, probably primarily by satellites. However, it is not at present clear whether the GSP should be held to a five-year limit; what the nature of a follow-on monitoring programme might be; who would benefit from such a monitoring programme; and who would conduct such a monitoring programme? The Board agreed that these are important issues which should first be considered by the GSP Scientific Committee.

EUROPEAN SPACE AGENCY (ESA) ACTIVITIES OF INTEREST TO AOSB

It was reported by Dr. Ola Johannessen that the satellite receiving station in Tromsø can receive images at a very rapid rate and can process an image in a matter of minutes. Last year a cruise was conducted to validate SAR imagery. When a lead exists and there is wind, the SAR imagery is exceptionally clear. When the ice has many edges, there is a lot of backscatter. The backscatter data for different ice types can be delineated (e.g. first-year ice, multi-year ice,

refrozen leads, etc.). Biological surfactants can affect the ocean surface in areas of eddies and permit the SAR to locate such eddies. Pressure ridges can be seen from images after image enhancement.

SAR imagery can be made available for the GSP and polynya studies depending on the interest of the scientists and the cost of the work. Images can cost around \$600 each for scientists not involved in ESA programmes. It was noted that the scientists involved in Greenland Sea studies are allocated sixty free images. The SAR is an "alternate" to scatterometer measurements, the latter providing very good surface wind measurements. There has been no degradation in any of the ERS-1 sensors to date; even recalibration has not been necessary. The orbit has been very well-maintained so that no orbit corrections have been necessary. As a result, the satellite will have enough fuel to keep the satellite up for ten years, assuming there are no equipment failures.

The ERS-2 is on schedule and within budget; it is expected to be available in late 1994 and to be launched in January 1995. ERS-1 will go into a 176-day repeat in late 1994 for geodetic purposes, so that a January 1995 launch for ERS-2 might be very timely for Greenland Sea purposes. The orbit for the ERS-2 has not yet been selected. PIPOR is arguing for the satellite to be launched into the same orbit as ERS-1 and phased within a few hours for data comparison, at least for an initial period.

ENVISAT-1 is scheduled to be launched in 1998 with an advanced SAR (ASAR) and multispectral scanner. This will also be able to measure atmospheric constituents. It is almost fully funded (8% short). Canada is also planning to launch RADARSAT in January 1995 with a similar SAR. This will be an industrial enterprise and is likely to generate very useful imagery, but at a high cost.

ARCTIC DATA BUOY PROGRAMME (IABP)

The written report from Dr. Victor Savchenko indicated that the IABP is making substantive progress towards development of a data network over the Arctic Ocean using drifting buoys that will permit the collection and distribution of standard meteorological and oceanographic data to users interested in the Arctic Ocean. It appears that scientific requirements for data buoy measurements are reaching the IABP and are being addressed effectively within this programme. The AOSB therefore decided that no further AOSB action in this area is needed.

ARCTIC OCEAN DATA MANAGEMENT

The Secretary of the IOC has indicated that it would welcome the AOSB's endorsement of an IOC mission to Russia to arrange for the rescue of Russian oceanographic data. **The Board asked Dr. Geoff Holland to contact the new Chairman of the IOC's Working Committee on Oceanographic Data and Information Exchange (WC/IODE), Ron Wilson, to request the WC/IODE to consider the needs for and possible approaches to identifying and developing a data center which would serve as a focal point for all arctic ocean data.** Such a center could hold a complete inventory of such data and be able to assist potential users to locate and acquire such data.

MARINE GEOLOGICAL AND GEOPHYSICAL RESEARCH IN THE ARCTIC OCEAN/NANSEN ARCTIC DRILLING PROGRAMME (NAD)

Dr. Leonard Johnson reported that the Scientific Committee of NAD had set up a small secretariat; developed a science plan; begun issuing a biannual newsletter; is considering potential research sites in the Mackenzie and Lena River deltas; and is considering a range of related issues, such as data management. The Committee is considering using a commercial drill ship to drill holes in the Mackenzie and Lena deltas. A final decision awaits analysis of industry

data from the Mackenzie delta and planned site surveys in the Lena delta. The availability and cost of Russian platforms is also being evaluated. Geological and geophysical data is to be collected on various transect expeditions to be conducted over the next few years. Magnetic data is being collected from existing sources under a joint Canadian-Russian-U.S. effort.

The R/V *Polarstern* is scheduled to conduct multi-channel seismic reflection studies in the Russian shelf seas, particularly on the eastern Barents and Laptev Sea shelves. It is not yet clear whether clearance for the science can be obtained or whether approval can be obtained to use the "Northern Route". An alternative programme in oceanography, biology and geology will be conducted in the same areas if permission for multichannel seismics cannot be obtained. It was noted that, while in the future the bilateral clearance process normally used might be augmented usefully by multilateral endorsements by organizations such as the AOSB and IASC, for the time being the bilateral mode appears to be the best way to seek clearances for research.

IASC has set up a marine geology working group to stimulate information exchange and scientific cooperation within the Arctic marine geology community. The group intends to identify goals for marine geosciences in the Arctic; develop input from the marine geosciences perspective to multidisciplinary programmes, especially those related to global change; address data management and related issues; and advise the IASC Council with respect to marine geosciences issues.

The Board was generally of the view that the scientific approach which had been identified by NAD is both sound and innovative. The Board invited NAD to return to the Board if NAD considers that the Board's consideration and potential endorsement of NAD-related issues would be useful in future.

IGBP

The IGBP develops initiatives for interdisciplinary global research projects. In this process, they recognized that to conduct such research on a truly global scale requires substantive involvement of developing countries through the System for Analysis, Research and Training (START) programme. The Scientific Committee on Antarctic Research (SCAR) developed a response directly for the Antarctic region and the IASC is developing a response from the Arctic perspective.

Dr. Gunther Weller is leading the IASC effort and is focussing the initial effort very appropriately on identifying the scientific needs for study of global change research in the Arctic. It should be kept in mind that START is intended to address not only IGBP needs but also those of the WCRP and HDP.

ARCTIC CLIMATE SYSTEMS (ACSYS) PROGRAMMES

Dr. Ed Carmack pointed out that the ACSYS programme has developed out of the WCRP working group on sea ice and climate. The two key questions which the ACSYS scientific steering committee seeks to address are: (a) Is the Arctic as sensitive to global climate change as models have suggested? and (b) Can the Arctic have a significant impact on global climate change? A document on the scientific objectives of ACSYS has been published by the WCRP and a scientific steering committee has been formed.

Scientists have suggested that proper mapping; monitoring; and modelling of the Arctic (a "3M approach") is needed to improve understanding of the role of the Arctic in climate change research. A Canadian review of the scientific objectives of ACSYS identified a number of activities which might contribute to ACSYS efforts related to atmospheric forcing; ocean circulation; fresh water cycle; sea ice; and climate modelling. Canada has been asked to host the

ACSYS offices, but no decision has been reached.

It is not clear whether the WCRP (and ACSYS) in particular will focus on the physical sciences. However, the World Meteorological Organization (WMO) is primarily interested in developing better databases to provide input for meteorological models. It was pointed out that, while the ACSYS report indicates that ACSYS will submit a science plan, the report does not identify either the GSP or the IAPP as ongoing programmes associated with or contributing to ACSYS.

The Royal Society of Canada has set up the Canadian global change programme which includes an Arctic panel that has been tasked with developing an Arctic (research) policy for Canada. The Society has initiated this effort through a series of subject-oriented workshops that will address physical processes, biological consequences and human dimensions.

Dr. Holland emphasized that, with the financial constraints that all science agencies are facing, effective coordination of research becomes even more essential than ever before and it becomes increasingly important to assure that the limited funds available for science in the Arctic are spent as effectively as possible. It was pointed out that one casualty of budget problems might be the loss of the Vostok ice core because the laboratory at St. Petersburg which is storing this core can no longer absorb the cost of doing so.

The Board thanked the WCRP Planning Office and Dr. Carmack for their update on ACSYS. The Board indicated their support for continued planning of ACSYS and will request ACSYS to keep in mind that AOSB programmes such as the GSP and IAPP should be included among Arctic Ocean-related research programmes that bear on and would in turn be affected by ACSYS.

RESEARCH VESSEL OPERATIONS IN THE ARCTIC

It was reported that the International Ship Operators group (ISOM) is continuing its support for an international electronic data base (OCEANIC) on ship operations, including Arctic ship operations. The data base is able and willing to receive the data for icebreakers and supply vessels but very little data has been received to date because the operators of these vessels do not perceive a direct benefit to themselves to do this. **The Board requested its members to encourage their appropriate national authorities to submit information to OCEANIC on the operating schedules and availability of icebreakers and supply ships.**

INTERNATIONAL ARCTIC SCIENCE COMMITTEE

Dr. Pentti Mälkki noted that IASC had convened a workshop to consider global change in the Arctic and to develop a draft science plan for a global change research programme for the Arctic. It was agreed in the workshop that substantial social changes in the Arctic may result from global change. The workshop sought to identify needs for global change research in the Arctic; to identify ongoing programmes to meet these needs; and to then identify the areas in which additional work needs to be done that is not now being done.

The Council considered setting up an IASC Secretariat for global change research, but delayed a decision pending further review of the role of regional centers in the Arctic, such as that being considered in conjunction with START. IASC decided that it should act as a scientific advisory body to AMAP. However, AMAP is already interacting with national scientific organizations on many levels and it was thus not clear to what extent AMAP would seek scientific advice from IASC. IASC has also set up ad hoc groups on marine geological and geophysical mapping of the Arctic Basin; on marine geology (referenced earlier); on Arctic glaciers; and on global change research.

The status of the IASC budget is not yet known, since it is not clear what if any funds IASC can expect from its members. Norway has organized funds for the small IASC Secretariat and its offices. A budget is necessary for additional staff; travel for Council and Executive Committee members; workshops; and similar meetings. If an IASC global change secretariat is set up in Helsinki, it will be wholly supported by Finland. Dr. Norbert Untersteiner has accepted a lead responsibility for developing a draft long-term strategy for IASC through a small group.

The Board asked its incoming Chairman to assure that IASC is kept informed of AOSB activities and vice-versa. The Secretary was asked to assure that the IASC Strategy and the report of the IASC Workshop on Global Change or the sections of the report that deal with ocean research are distributed to AOSB members for their information and/or comment as soon as possible.

SCIENTIFIC COMMITTEE ON OCEANIC RESEARCH (SCOR)

Dr. Robin Muench, the observer designated by SCOR, stated that SCOR operates primarily through working groups devoted to addressing at a very early planning stage specific scientific problems in a broad range of ocean science disciplines. In addition, SCOR is managing the JGOFS planning activity. SCOR also sponsors scientific workshops and/or planning meetings on specific ocean science-related topics. The Joint SCOR-IOC Committee on Climate Changes and the Ocean (CCCO) has recently been dissolved and has been reconstituted to primarily address the Global Ocean Observing System (GOOS).

INTERNATIONAL COUNCIL FOR THE EXPLORATION OF THE SEAS (ICES)

It was suggested that ICES is undergoing a transition from a traditional fisheries oriented focus to a broader emphasis on fisheries and environment focus. ICES has a data management capability and, in fact is the repository for the GSP data. A parallel organization is coming into being in the Pacific--the North Pacific Marine Sciences Organization (PICES).

ELECTION OF OFFICERS

Dr. Pentti Mälkki was elected as Chairman of the Board for a two-year period. Dr. Geoff Holland was elected Vice-Chairman. The outgoing Chairman expressed her appreciation for the excellent cooperation she had received during her three years as Chairman. She was pleased to note that Arctic ocean research has received increasing attention during this period.

FUTURE AOSB ACTIVITIES AND ARRANGEMENTS FOR THE NEXT MEETING

Dr. Jan Stel extended an invitation to the Board to meet next in Scheveningen near The Hague. The Board accepted this invitation with pleasure. It was agreed to try to limit the meeting to two days to be preceded by a one day meeting of the SCG/IAPP.

The Chairman invited discussion on the agenda of the next meeting and on the overall future programme for the AOSB. Dr. Mälkki suggested that paleoclimatology would be an interesting and appropriate area for AOSB focus. It was suggested that study of the Quaternary record from sediment cores in the shelf region may be a major gap in planning of the PAGES/NAD programme. Dr. Fütterer endorsed paleoclimatology as a topic of high potential interest to Arctic Ocean research and specifically to the AOSB. He recommended, though, that it might be useful for the AOSB to focus on a more specific scientific problem within this field, such as (a) variability in the flux of inputs to the Arctic Ocean or (b) Arctic post-glacial shelf processes.

Freshwater inputs to the Arctic Ocean, both in the historical record and at present, would include study of the rivers, sea-ice and glaciers. **The Secretary was asked to arrange for Board Members to receive the paper on fresh-water runoff to the Arctic Ocean which had been co-authored by Dr. Carmack a few years ago.**

The Board invited Dr. Fütterer to investigate with Arctic Ocean marine geologists what the geological boundary conditions for a potential AOSB Arctic Ocean paleocimatology programme might be and to consult in this process with Drs. Leonard Johnson; Geoff Holland; Ed Carmack; and Pentti Mälkki. Dr. Fütterer agreed, noting that meetings of the IOC and IASC meetings scheduled for early 1993 would provide an opportunity to refine this process. He agreed to prepare a report of his discussions for distribution to AOSB members.

Dr. Holland pointed out that a great deal of expertise in Arctic research may soon be lost as some of the senior scientists in the field retire or otherwise leave the field. He suggested that AOSB might promote training of young scientists in Arctic ocean research and involve these senior scientists in this training, thus transferring some of the existing capability to young researchers.

It was acknowledged that training for Arctic scientists is primarily undertaken at the national level, but that there might be some activities in this area which would be appropriate for the Board to promote. For example, the convening of scientific workshops helps to involve young scientists more fully in Arctic research. **It was agreed to look into the opportunities for sponsoring in 1995 or 1996, in conjunction with NATO, a summer school/workshop similar to the NATO Advanced Study Institute on Arctic Ocean research of a few years ago.**

It was also suggested that the Board might commission the preparation of scientific papers which would provide useful input for the policy process in those areas in which such scientific input would be useful. **It was agreed that the Newssheet could be used to communicate information to policymakers.**

CLOSING OF THE MEETING

The Board expressed its appreciation to the outgoing Chairman for her very effective leadership and her dedication to the work of the AOSB over the past three years. The Chairman then closed the meeting.