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FALL 1991

# ARCTIC RESEARCH

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OF THE UNITED STATES

INTERAGENCY ARCTIC RESEARCH POLICY COMMITTEE

## About the Journal

The journal *Arctic Research of the United States* is for people and organizations interested in learning about U.S. Government-financed Arctic research activities. It is published semi-annually (spring and fall) by the National Science Foundation on behalf of the Interagency Arctic Research Policy Committee and the Arctic Research Commission. Both the Interagency Committee and the Commission were authorized under the Arctic Research and Policy Act of 1984 (PL 98-373) and established by Executive Order 12501 (January 28, 1985). Publication of the journal has been approved by the Office of Management and Budget.

*Arctic Research* contains

- Reports on current and planned U.S. Government-sponsored research in the Arctic;
- Reports of ARC and IARPC meetings;
- Summaries of other current and planned Arctic research, including that of the State of Alaska, local governments, the private sector and other nations; and
- A calendar of forthcoming local, national and international meetings.

*Arctic Research* is aimed at national and international audiences of government officials, scientists, engineers, educators, private and public groups, and residents of the Arctic. The emphasis is on summary and survey articles covering U.S. Government-sponsored or -funded research rather than on technical reports, and the articles are intended to be comprehensible to a nontechnical audience. Although the articles go through the normal editorial process, manuscripts are not refereed for scientific content or merit since the journal is

not intended as a means of reporting scientific research. Articles are generally invited and are reviewed by agency staffs and others as appropriate.

As indicated in the U.S. Arctic Research Plan, research is defined differently by different agencies. It may include basic and applied research, monitoring efforts, and other information-gathering activities. The definition of Arctic according to the ARPA is "all United States and foreign territory north of the Arctic Circle and all United States territory north and west of the boundary formed by the Porcupine, Yukon, and Kuskokwim Rivers; all contiguous seas, including the Arctic Ocean and the Beaufort, Bering, and Chukchi Seas; and the Aleutian chain." Areas outside of the boundary are discussed in the journal when considered relevant to the broader scope of Arctic research.

Issues of the journal will report on Arctic topics and activities. Included will be reports of conferences and workshops, university-based research and activities of state and local governments and public, private and resident organizations. Unsolicited nontechnical reports on research and related activities are welcome.

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## Front Cover

*Leads in Arctic sea ice. From the poster for the Office of Naval Research workshop on Air-Ice-Ocean Interaction, 12-14 November 1990, Arlie, Virginia. Photograph by Neelon Crawford.*

# ARCTIC RESEARCH

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Editorial	3
The Coordinated Eastern Arctic Experiment: A Progress Report	5
The Arctic Gas and Aerosol Sampling Program	14
The Arctic Research Consortium of the U.S.: Creating a Synergy for the Arctic	17
Managing the Arctic's Resources	26
Arctic Environmental Protection Strategy	29
Recent U.S.-U.S.S.R. Agreements Relating to the Bering Region	37
New Marine Science Organization in the North Pacific	48
The Alaska Sea Grant College Program: At Home in the North	50
News in Brief	
<i>The First Meeting of the International Arctic Science Committee</i>	54
<i>Arctic Activities under the U.S.-U.S.S.R. Agreement on Cooperation in the Field of Environmental Protection</i>	55
<i>U.S.-U.S.S.R. Agreement on Cooperation in Ocean Studies</i>	56
<i>U.S.-Iceland Workshop on Scientific Cooperation in the North Atlantic</i>	58
<i>Northern Forum Update</i>	60
<i>Beringian Quaternary Terrestrial Research</i>	61
<i>Federal Arctic Research Workshop</i>	63
<i>The Alaska Synthetic Aperture Radar Facility: Update</i>	65
<i>Alaska Science and Technology Foundation</i>	67
<i>Glacier Research Workshop</i>	70
<i>Interagency Multimedia Data Product</i>	70
Report of Meeting	
<i>United States Arctic Research Commission</i>	72
Forthcoming Meetings	75
Interagency Arctic Research Policy Committee Staff	78
Illustration Credits	79





*Arctic Research Commission meeting at Barrow, Aug. 1991. Left photo (left to right): Oliver Leavitt, Donald O'Dowd, Walter Massey, John Steele, Ben Gerwick, Elmer Rasmuson. Below (left to right): Oliver Leavitt, Donald O'Dowd, Ben Gerwick, Elmer Rasmuson, John Steele.*



*Meeting of the eight Arctic countries to sign the Declaration on the Protection of the Arctic Environment, June 1991. Above: Ministers and representatives of the eight countries. Right: U.S. Ambassador John Weinmann (standing) in discussion with other members of the U.S. delegation.*





Walter Massey  
*Chairman*  
Interagency Arctic Research  
Policy Committee



Donald D. O'Dowd,  
*Chairman*  
Arctic Research Commission

## *An Arctic Obligation*

As new chairpersons we are both in our first months of stewardship of the efforts envisioned by the Arctic Research and Policy Act of 1984. We extend our thanks to our predecessors for their efforts in developing and furthering the goals, priorities and activities necessary to pursue a coordinated Federal research program in the Arctic.

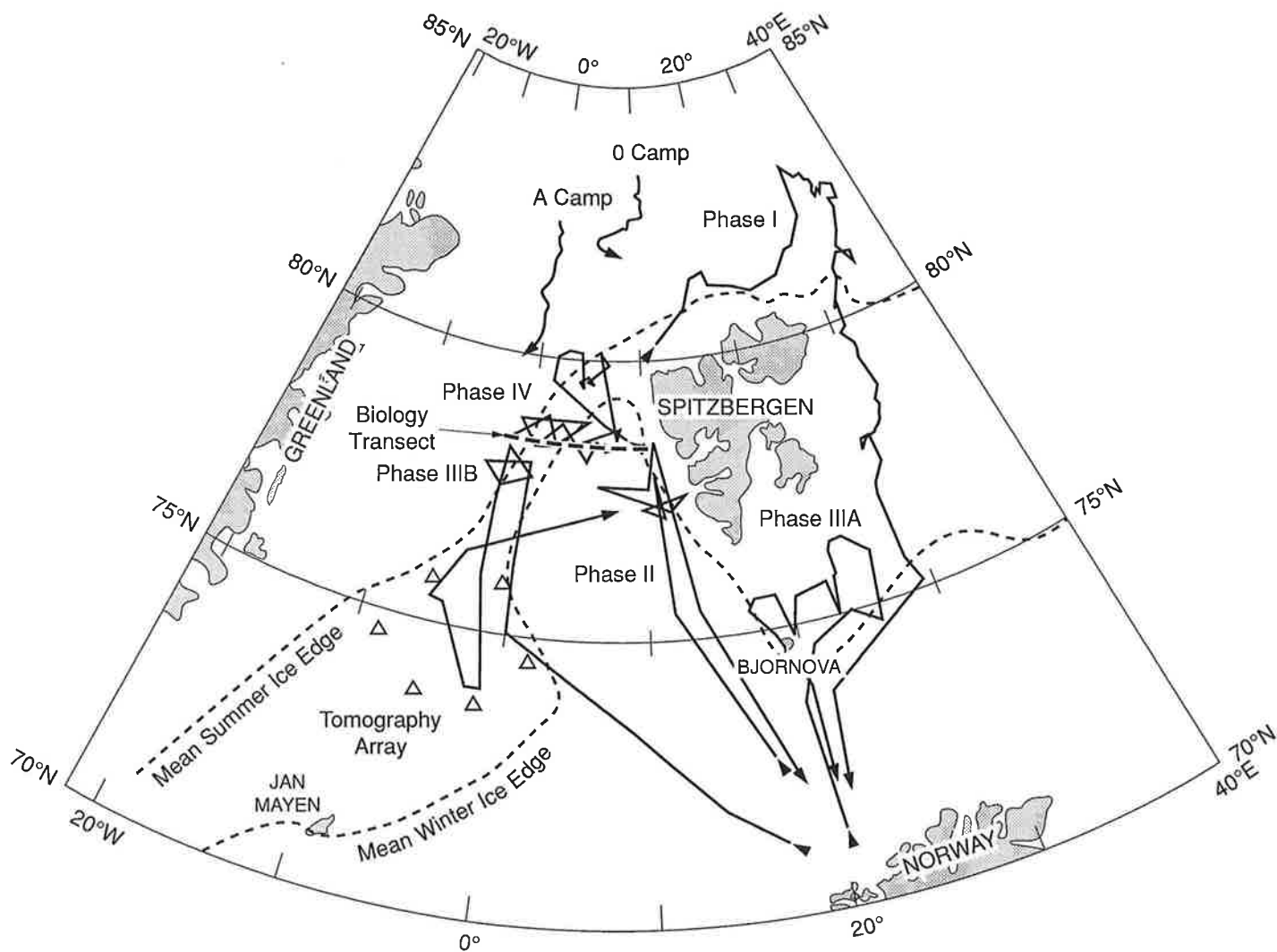
The first Congressional hearing on Arctic research in seven years was in April 1991 before the Senate National Ocean Policy Study of the Commerce, Science and Transportation Committee. At that hearing testimony by the Interagency Committee, the Arctic Research Commission, the Polar Research Board of the National Academy of Sciences, and the Arctic Research Consortium of the U.S. was presented. Collectively the record of that hearing represents another status report to the Nation of our progress and the challenges in Arctic science. The Senators heard testimony on the importance of Arctic issues for national energy, environment, health, resource development and management, and national security policies. The hearing signified increasing interest in the Congress for support of Arctic research.

Meanwhile, international momentum in the Arctic is increasing, as indicated by the formal organization of the International Arctic Science Committee and the agreement to organize the North Pacific Marine Science Organization (PICES). In June 1991 the eight Arctic countries signed a declaration and action plan for an Arctic Environmental Protection Strategy. The recently completed geoscience

expedition to the central Arctic aboard the ice-breakers U.S. *Polar Star*, German *Polarstern* and Swedish *Oden* in mid-1991 is a demonstration of international collaboration in the world's least studied ocean. Such domestic and international momentum is encouraging.

The second biennial revision of the U.S. Arctic Research Plan, published in the preceding issue of *Arctic Research of the United States* (Vol. 5, Spring 1991), charts the direction for Federal Arctic research. This Plan includes important inter-agency programs for the study of 1) western Arctic Ocean circulation and productivity; 2) geodynamics of the Arctic Basin and its margins; 3) Arctic monitoring 4); the Bering land bridge and its heritage; and 5) a program for Arctic data and information. There are many other exciting projects within agency programs from archaeology to zoology, and effort is also focused on logistic support of Arctic research.

Our experiences in Alaska this past summer suggest that the challenges and opportunities for Arctic research are many. The scientific community is dispersed and programs are driven by diverse agency missions. Certainly the presentations by Native Americans that we heard at the Commission meeting in Barrow in August support our view that we can and must do better together to realize more effectively the potential of our Nation's investment in the Arctic. It is our commitment, and our challenge to you, to continue to promote improved cooperation among agencies and among research programs, both domestically and internationally.



#### Operations during the Coordinated Eastern Arctic Experiment (CEAREX).

Phase I (pack ice)	17 September 1988–7 January 1989 (ice-fast ship)
Phase II (Whaler's Bay)	17 January 1989–2 February 1989 (ship)
Phase IIIA (Barents Sea MIZ)	9 February 1989–4 March 1989 (ships, aircraft)
Phase IIIB (Greenland Sea MIZ)	10 March 1989–1 April 1989 (ships, aircraft)
Phase IV (Fram Strait MIZ, pack ice)	7 April 1989–18 May 1989 (ship, aircraft, ice camps)

# *The Coordinated Eastern Arctic Experiment*

## *A Progress Report*

ROBIN WILLIAMS, THOMAS CURTIN AND JOSEPH FONDRAK

During the period September 1988 to May 1989 the Coordinated Eastern Arctic Research Experiment (CEAREX) was staged. This field program, sponsored principally by the Office of Naval Research, involved over two hundred scientists and technicians from seven countries. The objectives of the program were to obtain a better understanding of the structure and function of meso-scale to small-scale processes in the Arctic Ocean inlet region near Svalbard and the associated ambient acoustic noise field. This paper is a progress report on the data analysis one and a half years after the completion of the field program (see *Arctic Research of the United States*, Fall 1988, p. 44; Spring 1989, p. 14, and Spring 1990, p. 55, for prior reports).

### *Background*

Throughout the Arctic Ocean, a well-defined halocline (pycnocline) separates the surface mixed layer from the so-called Atlantic Water, a layer of relatively warm salty water that extends from approximately 200 to 500 m. Freezing on the surrounding shelves possibly maintains this halocline through the production of saline water. River discharge contributes significantly to the surface layer, which includes the ice cover. Advection in the eastern Arctic through the Fram Strait region outputs surface-layer water and ice and inputs Atlantic Water. Fluxes through this region maintain the structure of the upper water column above and below the halocline throughout the Arctic.

Through the 500-km-wide Fram Strait, the West Spitzbergen Current (WSC) carries warm Atlantic Water northward into the Arctic Basin, while cold polar surface water and ice outflows as the East Greenland Current (EGC). The upper-level velocity field associated with these boundary currents is highly variable, with prevalent meso-scale eddy activity. Mass transport estimates of the WSC from direct current measurements, geostrophic and salt balance calculations vary between 1.5 and 7.0 Sv. Annual mean transport estimates of sea ice and latent heat in the EGC are 0.1 Sv and  $3 \times 10^{-13}$  W ( $\pm 20\%$ ), equivalent to ice 30 cm thick over the central Arctic.

Within the WSC, subduction transforms Atlan-

tic Water as it penetrates northward. Candidate physical phenomena involved in this transformation include frontal instabilities, mesoscale eddies, topographic interaction, surface stress divergence/curl, inertial/internal waves, and boundary layer/interior turbulence. The relative importance of the different physical processes in regulating the transport and mixing of Atlantic Water into the Arctic Ocean is yet to be determined.

Vertical transport associated with physical processes also regulates nutrient fluxes and biological production. Modulated by the seasonal cycle of incident solar radiation, primary productivity in this region reaches the global maximum. Trophic level interaction (particularly the timing and intensity of grazing) and feedback between biological and physical processes determine net production. The controlling mechanisms, including the distribution and function of specific organisms, are not well understood.

In the WSC-EGC exchange process, ice motion and deformation forced by atmospheric and oceanic stress fields and ice growth and ablation in response to radiative and sensible heat fluxes contribute significantly to the redistribution of mass and energy. In addition to large-scale advection of latent heat in the EGC, fracture and floe interaction produce localized transports that may trigger instabilities in the atmospheric and oceanic boundary layers. The subduction of Atlantic Water in the WSC occurs beneath the ice cover, which governs momentum and heat fluxes at the sea surface. The macroscale response of this inhomogeneous floating ice plate to nonuniform applied forces including thermal stresses needs to be related to micro-scale processes and properties. Energy dissipation in the ice is indicated by the acoustic ambient noise spectrum. Noise detection depends critically on poorly understood factors limiting the coherence of acoustic propagation near the ice/ocean interface.

The Coordinated Eastern Arctic Experiment (CEAREX) was organized to address the dynamics and interactions regulating eastern Arctic Ocean exchanges of momentum, heat and biomass. Understanding the structure and function of mesoscale and submesoscale processes in the transport of heat northward and understanding the associated acoustic ambient noise and coherence were the primary CEAREX objectives.

*Robin G. Williams is at the Department of Oceanography, U.S. Naval Academy; Thomas B. Curtin and Joseph Fondrak are both with the Office of Naval Research.*

# CEAREX Operations Summary

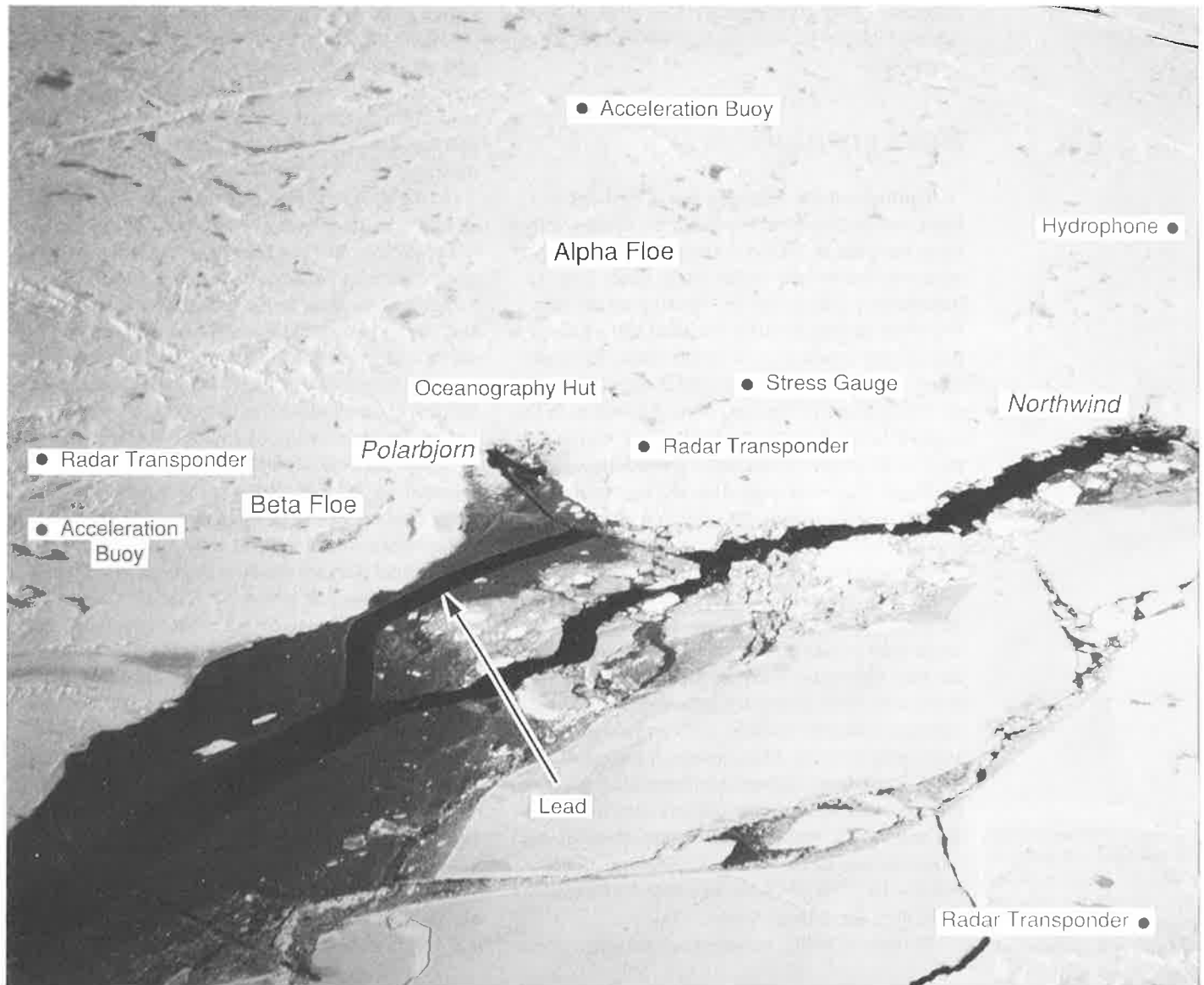
CEAREX encompassed the following seven distinct but complementary Arctic field operations conducted from 1 September 1988 to 26 May 1989:

- Winter Drift Operation (4 September 1988 to 10 January 1989), which focused on the mechanical behavior of sea ice resulting from drift and floe interaction, ice kinematics, heat flux, under-ice turbulence, upper ocean characterization, passive microwave signatures of sea ice, and ambient noise measurements;
- Whaler's Bay Operation (14 January to 4 February 1989), which estimated the absolute magnitude of the regional heat flux and the contribution of the horizontal and vertical

processes in the ocean microstructure on the Svalbard shelf, and made the first measurements of hydrogen peroxide production under winter conditions of minimum solar irradiance flux;

- Barents Sea Operation (6 February to 4 March 1989), a dual program for both CEAREX and the Norwegian SIZEX (Seasonal Ice Zone Experiment) program, which emphasized extensive studies of passive and active microwave signatures of winter sea ice and adjacent waters, investigations of coupled air-ice-ocean processes, current measurements and data to develop algorithms for satellite observations to validate ocean and ice forecast models;
- Greenland Sea Marginal Ice Zone (MIZ) Operation (11 March to 2 April 1989), which continued the Barents Sea investigations into the Fram Strait and Greenland Sea MIZ, emphasized investigation of the East Greenland Cur-

*Position of the MV  
Polarbjorn at the start of  
the Winter Drift Operation.*





rent and associated eddy structures, measurement of deep ocean convection in or near the Acoustic Tomography Array, and extensive remote sensing studies of the MIZ;

- Greenland Sea Biological Oceanography Operation (5 April to 18 May 1989), which studied the influence of ocean eddies on nutrient flux and primary production of the MIZ, the relationship between biological and oceanographic processes, nutrient uptake rates and ocean gradients, and detailed oceanographic investigation of warm core eddies and local circulation patterns in the upper 200 m of the ocean;
- Oceanography Ice Camp Operation (18 March to 1 May 1989), which investigated under-ice microscale to mesoscale oceanographic features, integrated several CTD studies including remote helo CTD stations, ice tilt and strain studies, under-ice surface mapping, bio-optical measurements in and under the ice, SOFAR drifter tracking and thermometer chains and current meters installed on a line to the Acoustics Ice Camp; and
- Acoustics Ice Camp Operation (21 March to 21 April 1989), which focused on ambient noise mesoscale processes; microscale phenomena and statistics; ULF and VLF noise source levels; coherence measured relative to time, space and environmental factors; observation of the GSP tomography signals; acoustic backscattering; seismic refraction and bottom interaction; physical oceanography of internal waves, current and CTD measurements; ice diffusion; bio-acoustics; and seawater chemistry.

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*This major research program involved 210 researchers and technicians from Canada, Denmark, the Federal Republic of Germany, Norway, New Zealand, the United Kingdom and the United States*

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A continuous Remote Sensing Research Program, with instrumentation based on shipboard, ice camps and helicopters, was integrated into all seven CEAREX operations. This was also supported by two SAR-equipped, fixed-wing aircraft: the Canadian Centre of Remote Sensing CV-580, which made six Barents Sea overflights between 15 and 27 February 1989, and the NADC P-3, which made ten Greenland Sea MIZ and Ice Camp overflights between 17 March and 16 April 1989. Similarly the Barents Sea acoustic survey was supported by a Royal Norwegian Air Force P-3 making sonobuoy airdrops on 18 and 27 February.

Finally the comprehensive Meteorological Program, which was an integral part of every CEAREX operation, was supported by the NOAA P-3, which made nine instrumented research flights between March 15 and 30: three to measure Arctic haze, three to survey Arctic lows, and three boundary layer investigations integrated directly with CEAREX ship and ice camp data.

This major research program involved 210 researchers and technicians from Canada, Denmark, the Federal Republic of Germany, Norway, New Zealand, the United Kingdom and the United States. Operations were based primarily aboard the chartered, ice-strengthened Norwegian MV *Polarbjorn*, with participation by the University of Bergen RV *Haakon Mosby* during part of the Barents Sea and Greenland Sea operations. The nine-month period of continuous operation for CEAREX called for a complex logistic, communication, personnel and scheduling coordination effort. All operations were completed successfully, and essentially all the research objectives were attained.

CEAREX's success is best demonstrated by the results of the program's Workshop and Publications Planning Meeting held on 7–10 February 1990, less than one year after the program's completion. Fifty-four attended the meeting, representing every operation and participating project. The CEAREX publication plan developed at that meeting lists 186 disciplinary reports and papers scheduled, which break down into the following disciplines:

Oceanography	40
Biology	20
Ice	31
Modeling	1
Meteorology	11
Interdisciplinary	33
Remote Sensing	17
Data reports	11
Acoustics	22

Data collected during CEAREX is being archived at the National Snow and Ice Data Center (NSIDC) in Boulder, Colorado. A subset of these data is available on CD-ROM and can be obtained by contacting Claire Hanson, who is coordinating the effort at NSIDC, University of Colorado, Boulder, Colorado 80309.

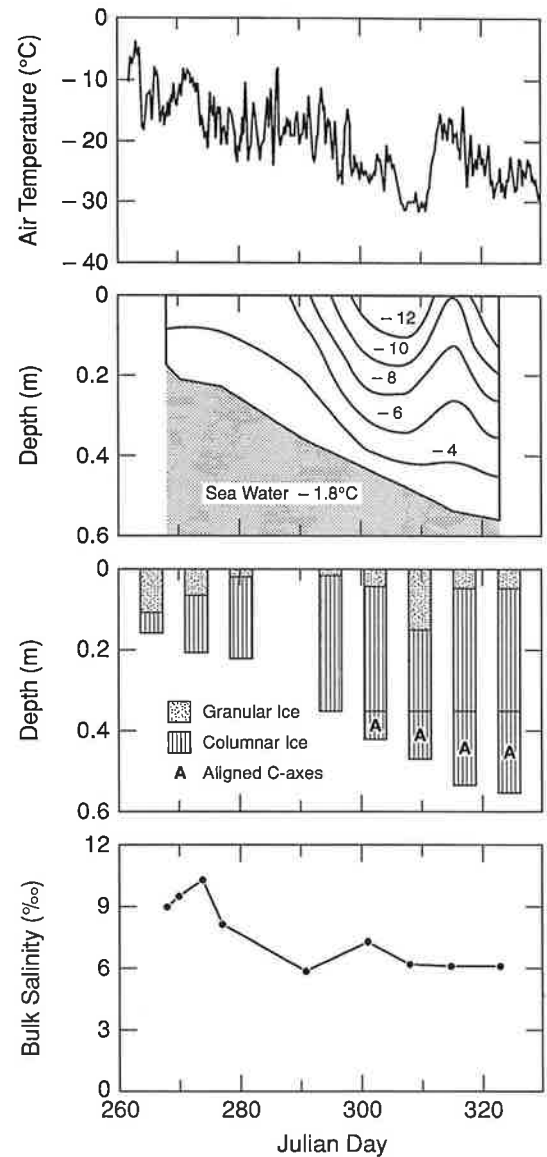
## *Important Results to Date*

The CEAREX data are still being analyzed, but already several important new results have been reported. As CEAREX was primarily a field program, the impact of these will likely be felt most in the area of modeling, where the new data will en-

able researchers to improve or construct models of the processes under investigation.

The Winter Drift Operation (WDO) provided a platform (MV *Polarbjorn*) from which scientists could measure, over a continuous period of two months, fall freeze-up conditions in the Arctic Ocean. Since this was the first opportunity to make these observations using state-of-the-art equipment, the data collected are, in most cases, unique and thus of considerable importance in areas where data were not available. A good example is ground-truth information for satellite-derived passive microwave data, which are routinely used by both the civilian and military communities to determine sea-ice type and concentration and the position of the ice edge. There are at least five algorithms for converting the brightness temperature sensed by the satellites to usable products. Discrepancies often exist between the outputs of these algorithms, principally because of the lack of ground-truth information essential for the calibration of the satellite data. For the polar regions, ground-truth data are extremely scarce. During the WDO, valuable ground-truth microwave data of both polarizations were collected in the frequency range of 6 to 90 GHz while a simultaneous record was kept of the ice conditions. From these, data plots were produced, showing how the emissivity, which relates the actual temperature of the ice to that sensed by the satellite, changes as a function of frequency and polarization for different types of multiyear ice. Information such as this is essential for determining ice type and calculating areal concentration.

On 16 September 1988 the MV *Polarbjorn* was moored in the pack ice at 82°40'N, 32°32'E (see the front cover of *Arctic Research of the United States*, Fall 1988). Adjacent to the ship, extending for several hundreds of meters, was a recently formed unfrozen lead, the proximity of which afforded a unique opportunity to conduct a detailed two-month study of a freezing lead, at the end of which the ice had grown to an average thickness of 0.56 m. During winter, leads and polynyas constitute the only sources of open water within the Arctic Basin, and it is here that the highest rates of ice production occur. It has been estimated that the total annual ice production associated with open leads and young ice (0–0.8 m thick) is nearly twice that of thicker ice. Most of this growth occurs during the fall and winter, when open water and thin ice make up only a small fraction of the total area of sea ice. Modeling studies show that turbulent heat losses to the atmosphere during fall and winter total about 200 MJ/m<sup>2</sup>, most of which arise from heat conducted from the ocean to the surface through the thin ice. The ice production



Characteristics of the recently formed unfrozen lead adjacent to the *Polarbjorn*.

and heat loss to the atmosphere are more than an order of magnitude larger for a freezing lead than for multiyear ice (3–4 m thick). Likewise the salt rejected into the ocean resulting from young ice production far exceeds that for thicker ice. These modeling studies confirm that young ice plays an important role in upper ocean processes in the Arctic. Understanding of these processes has suffered from a chronic shortage of field data. The CEAREX data and other data that will be collected during the upcoming ONR LEADDEX program will be of great value here.

Formulating realistic constitutive laws for sea ice, which exhibits complicated elastic, viscous and plastic behavior, remains one of the main challenges for the foreseeable future. During the WDO, considerable effort was devoted to measur-

ing stress and strain, the two variables that must be related to form a constitutive law. An important new discovery was that the horizontal stress field in the sea ice appears to vary with depth. This observation, which has recently been supported by independent theoretical calculations, has implications for modeling the internal ice stress term in the momentum equation for sea ice in atmosphere–ice–ocean coupled models. The vertical stress distribution in an ice floe represents in a mean sense the direct tractions on the upper and lower surfaces of the ice and the tractions applied by floe collisions and water pressure. It follows that the ice will have a vertical distribution of stress through its thickness. This effect, which is ignored in present models, could be important and is being investigated.

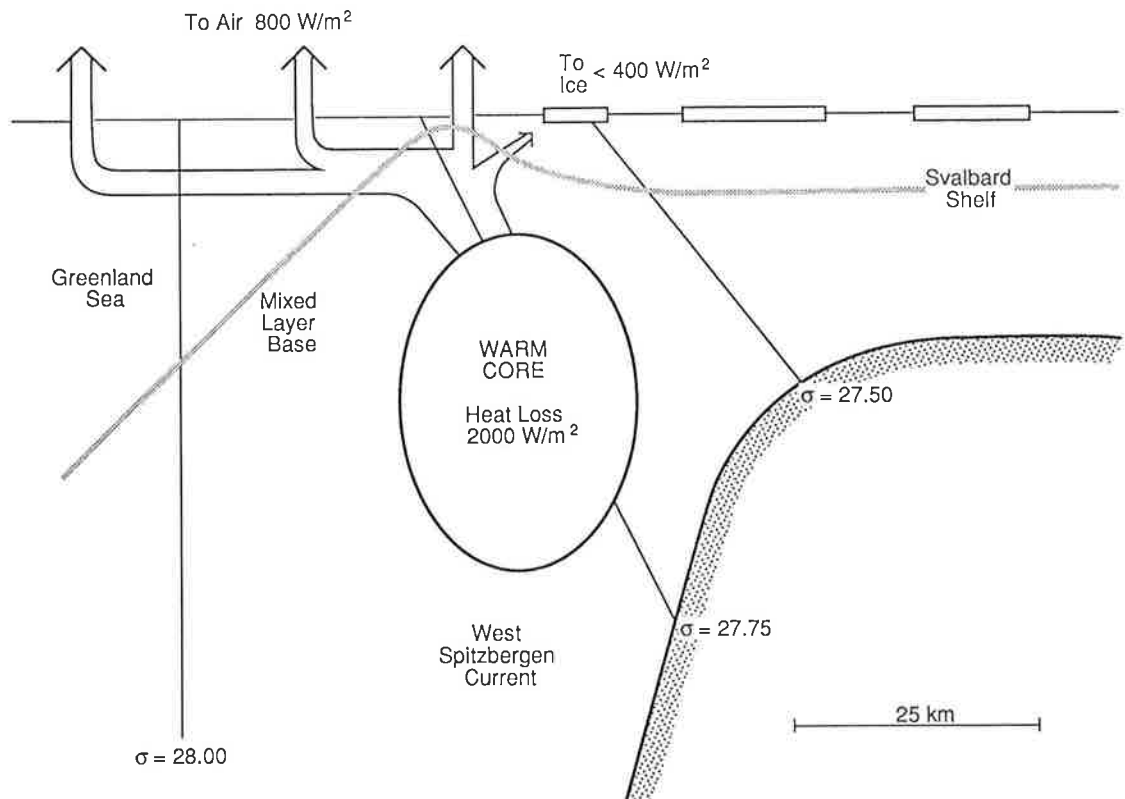
One of the major signals in the stress and strain fields is caused by ridging events, which result in the familiar “ice-scape” of sails on the surface and keels on the underside of the ice. The most dramatic episode during the WDO was a ten-day series of ridging events as the *MV Polarbjorn* drifted through the shear zone near Kvitoya Island. These events were captured on video as well as by a host of instruments ranging from accelerometers to hydrophones. The amount of ice crushed during the formation of these ridges was larger than expected and again suggests the need for new constitutive laws for the internal ice stress.

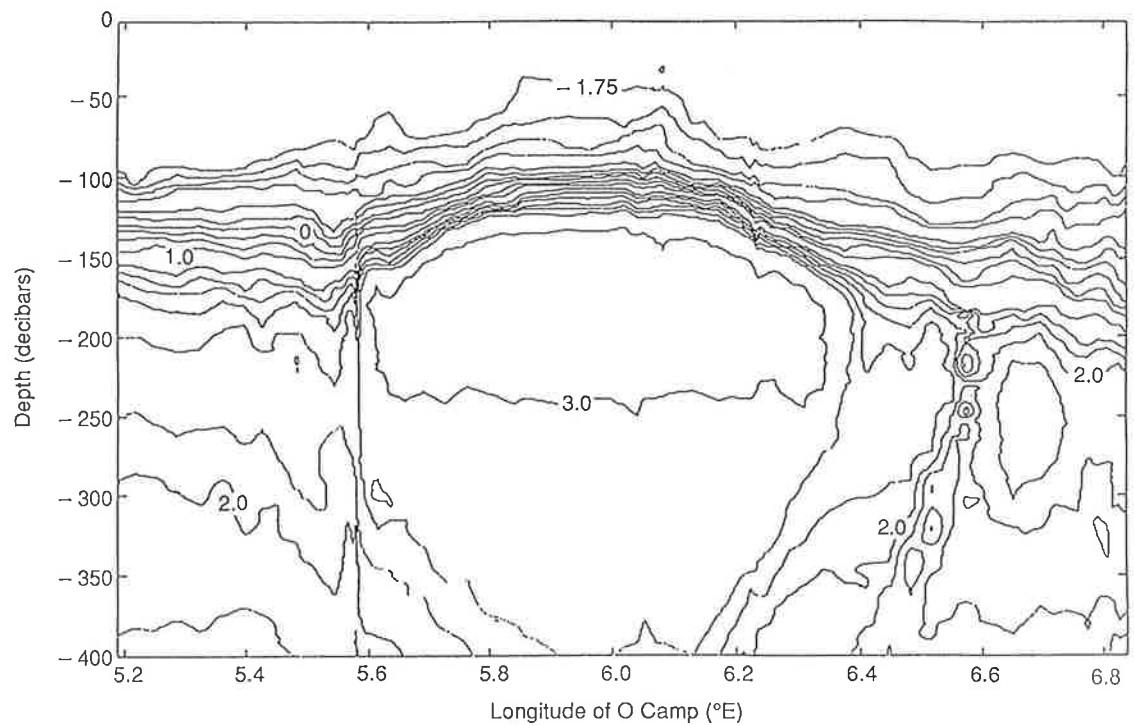
One of the central aims of CEAREX was to attempt to obtain a more precise estimate of the heat flux through the Fram Strait into the Arctic Basin

caused by the northward-flowing WSC. Experiments in January 1989 on the shelf and slope to the west of Spitzbergen showed that in winter, as the WSC flows northward, it cools dramatically along its path from 6°C north of Norway to 3°C off northern Spitzbergen. The warm core of the WSC on the slope region has a flow of 0.35 m/s and cools 0.5°C in 100 km. This corresponds to a heat loss of 2000 W/m<sup>2</sup> averaged over the study region, which is too large to be carried by a reasonable level of turbulent mixing. One conjecture is that the additional heat must be exported from the current into the Greenland Sea or Svalbard shelf by mesoscale eddies. These eddies are the means by which warm water from the core of the WSC is transported to the surface along isopycnals and cooled by contact with the atmosphere and ice. The Fram Strait region is rich in such eddies, some of which move northward into the Arctic Basin.

One of the outstanding achievements of the Oceanography Ice Camp (O Camp) was to thoroughly document the passage of such a warm-core eddy. It passed under the camp towards the end of April just as preparations were being made to abandon the camp due to break-up of the ice. The eddy’s velocity, temperature and current structure were thoroughly mapped. Although dissipation and small-scale temperature variance measurements were only made at the beginning of the passage of the eddy, it is clear that heat flux increased considerably upwards into the mixed layer as the

Winter heat loss processes in the Fram Strait west of Spitzbergen.





*Temperature structure (degrees Celsius) as a function of longitude for the eddy that passed under O Camp.*

warmer water was entrained into the upper colder water close to the ice. A map of the current structure of the eddy showed that it was a clockwise-rotating eddy with a diameter of about 10 km. Apparently the camp was not over the center of the eddy but over a sector from the east side to the southwest edge.

Measurements of tides in the Arctic are very scarce, so any signals that show diurnal or semi-diurnal variation are of particular interest. During the WDO, semidiurnal oscillations were recorded by several instruments, for example, ambient noise and stress and strain data. In contrast, during the O Camp drift, strong diurnal signals were observed as the camp drifted over the Yermak Plateau and closer to Svalbard. Diurnal signals have been observed in this region before, and a complex theoretical explanation exists that predicts a topographically enhanced diurnal tide over the Yermak Plateau. The current view is that the diurnal signal observed at O Camp is due to the diurnal internal tide and that this internal gravity wave is in some way related to the proximity of the steep topography of the Yermak Plateau. In general, areas of steep topography are usually associated with higher levels of internal wave energy, and the area over the Yermak Plateau is no exception. Indeed, the overall energy level of the internal wave field was found to be higher here than in other parts of the Arctic.

Riding on top of the crests of the conjectured internal diurnal tide were groups or packets of internal waves with a period of 24 minutes. This period corresponds to the observed buoyancy frequency at the pycnocline. These waves had ex-

tremely high amplitudes (about 35 m) and were heading away from the Yermak Plateau. These packets could be clearly observed in both the strain and tilt measurements of the sea ice that were recorded at O Camp, even though they caused a surface displacement of only a few millimeters. A model that couples these internal waves riding the pycnocline to the sea ice consists of a two-layer fluid representing the mixed layer and the deep ocean covered by a thin elastic sheet representing the sea ice. The surface manifestation of the internal waves causes the ice to flex vertically, which in turn causes variation in the horizontal strain field in the ice.

Measurements in the sub-ice boundary layer show that the presence of the high-energy diurnal internal wave field leads to increased levels of turbulence and vertical heat flux. These increased levels are probably due to internal wave breaking activity at the mixed layer/pycnocline interface.

Bottom water formation and deep convection are processes that occur at high latitudes and are thought to play an extremely important role in regulating the global climate. The accepted model for deep water formation in the Greenland Sea proposes that deep water is formed by the cooling of surface water during late winter, primarily in the Greenland Gyre where weak vertical stratification is observed in early winter. The cooled surface water sinks and is replaced by warmer water from below. Deep convection in the form of these "chimneys" has very rarely been observed. During SIZEX a "snapshot" of such a chimney was taken by scientists working in the Boreas Basin area of the Greenland Sea. The feature was 15–20 km in

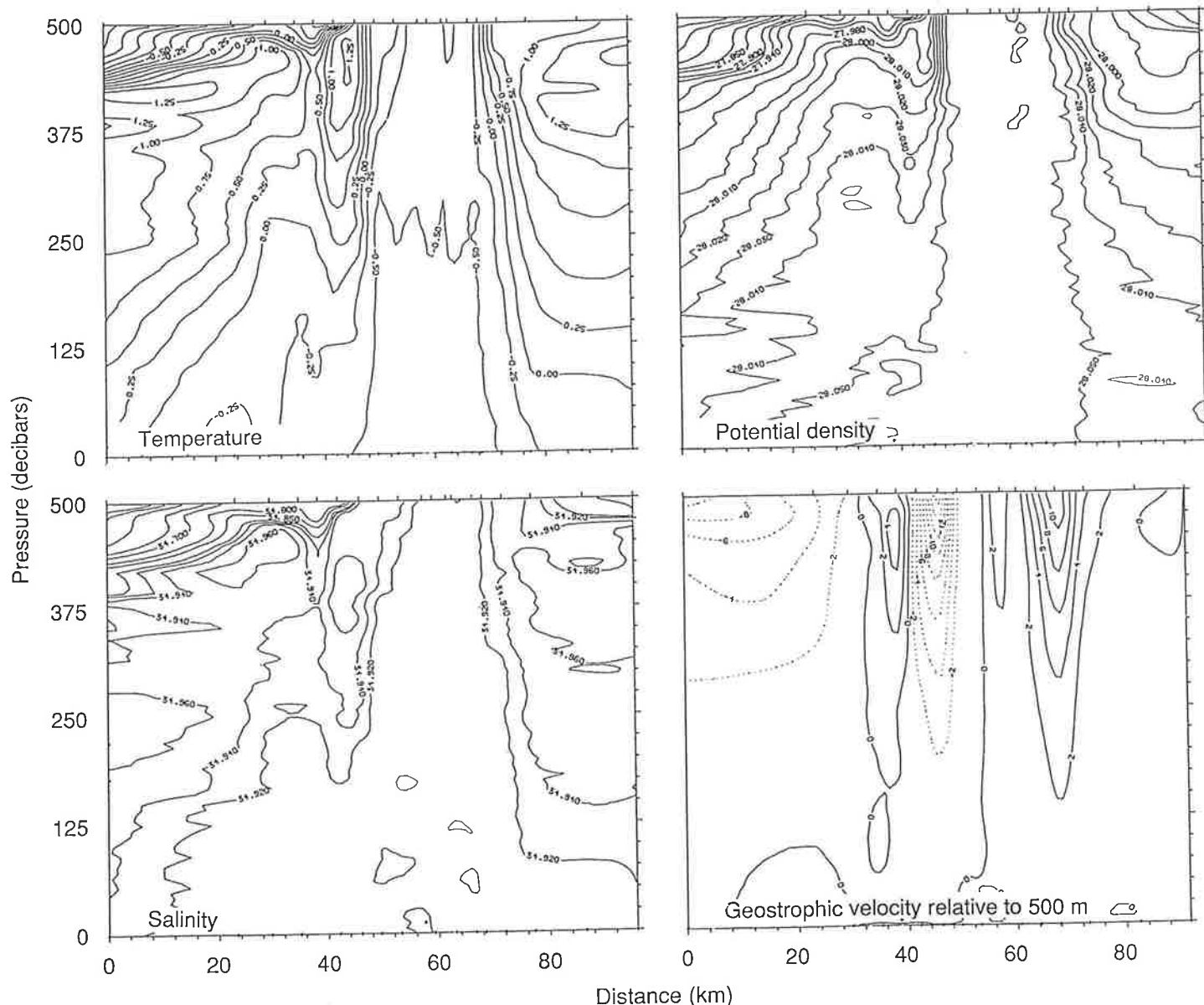


diameter in the upper 200 m, and from the surface to a depth of 2800 m the potential density increased only from 28.056 to 28.077. Surface cooling of only a few tenths of a degree Celsius is sufficient to initiate deep convection in such a feature.

A major element of CEAREX involved the measurement of ambient noise, both under continuous pack ice and in the MIZ. At the Acoustics Ice Camp Operation (A Camp), a low-frequency large-aperture array was deployed to measure the level, directionality and coherence of ambient acoustic noise up to 500 Hz. Ambient noise measurements under continuous ice cover were also made during the WDO phase. The mean measured ambient noise levels northeast of Svalbard were 20–30 dB higher than typical central Arctic Basin values. However, they compare favorably with other active ridging regions or dynamically active regions such as the MIZ.

In the MIZ, noise measurements were made during SIZEX and used to test a model developed for the UK Admiralty Research Establishment that predicts the characteristics of ambient noise in the MIZ from a knowledge of the environmental conditions such as the wind and wave fields. Three noise-producing processes are modeled: collisions between ice floes, compression of brash ice between floes and shearing contact between ice floes. The floe-pair interaction event rates suggested by the model agree moderately well with measurements. The variation in the interaction event probability of each process is investigated as a function of wave height. The ratio of the mean wave height to the mean floe spacing is a dominant factor in determining event rates of the first two mechanisms. The model quantifies the intensity with which these processes occur in order to estimate how great a contribution to the ocean

*"Snapshot" obtained from the MV Polarbjorn across a cyclonic eddy at 78°15'N. In the center of the eddy, a chimney of deep water masses, approximate 20 km in diameter, is lifted to the surface. The stratification in the chimney is very low. Deep water formation may occur in this chimney if surface cooling is sufficient.*



noise field each process might make. The variation in intensity of each process is investigated as a function of ice and wave conditions at any point within the MIZ. The model shows that each process is confined to a region of the MIZ, the extent of each region depending on the exact conditions that are specified. Correlations between the model output and ambient noise measurements indicate that some features of the ocean sound field are predicted well by this model.

Finally, in the field of biological oceanography, a significant discovery was made by a team working from the MV *Polarbjorn* in the Greenland Sea. Their west-east transect across the Fram Strait showed a massive spring bloom of a species of phytoplankton known as *Phaeocystis*. A significant amount of carbon is being fixed in the upper ocean by this species. From measurements of the rate of removal of nitrate from surface waters, it was calculated that the average regional new production was about  $40 \text{ g}^\circ\text{C}\cdot\text{m}^{-2}$  during the 35-day period of the observations. This rate of new production is approximately equal to that observed in other hyperproductive polar regions, such as the Bering Sea and the Bransfield Strait. Because *Phaeocystis* blooms seem to be frequent and widespread, the results suggest that the Greenland Sea may be a larger sink of atmospheric carbon dioxide than had previously been thought.

## Summary

In this age of satellites, it is not surprising that one of the major efforts of CEAREX focused on collecting ground-truth observations in order to calibrate satellite-derived data. Sea ice was of particular concern, as existing algorithms for converting raw signals to usable products such as ice type and concentration very often give different results. This discrepancy occurs principally because of the lack of ground-truth data for testing models. The data collected during CEAREX will help correct this deficiency.

In the field of ice mechanics, observations of ice stress and strain lead us to question the existing constitutive laws for sea ice, which do not accurately model the complicated elastic-viscous-plastic behavior of sea ice. Developing improved sea-ice models is the central goal of a new ONR initiative, and these field data will be of great value in this effort.

The issue of how heat is transported to and within the Arctic Basin was addressed by several investigators. As a result a much-improved de-

scription is now available of how heat is transported via the West Spitzbergen Current into the Arctic Basin and adjacent seas. The crucial role eddies play in this process was also studied. In this context, one of the major achievements of CEAREX was the detailed mapping of the structure of a warm core eddy as it hugged the bathymetry of the Yermak Plateau on its journey into the Arctic Basin. Interesting observations include what are thought to have been fish, trapped in the interior of this warm eddy. Experiments in the Fram Strait and over the Yermak Plateau quantified heat fluxes associated with the various transport processes, such as heat loss to the atmosphere and the melting of ice.

On the east side of the Arctic Basin we have learned that the internal wave field is much more energetic than in regions farther west in the Arctic Ocean. The difference in levels is approximately an order of magnitude, and the level north of Svalbard is comparable to the values typical for mid-latitudes. A very strong internal diurnal tide was observed above the Yermak Plateau, together with high-amplitude packets of internal waves heading north. Clearly the steep topography of the Yermak Plateau is playing an important role here, and modeling work is currently in progress to understand the nature of that role.

With the increased awareness of the importance of high-latitude deep convection in regulating global climate change, it was satisfying to learn that a Norwegian group, working in the Greenland Sea, had the rare opportunity to record this process by mapping the structure of a "chimney," the presence of which can lead to deep convective overturning. Also, for the first time, very large blooms of the plankton *Phaeocystis* were observed in the Greenland Sea. This observation leads to the important conclusion that the Greenland Sea could be a much larger sink for atmospheric carbon dioxide than was previously thought.

Finally, in the field of underwater acoustics, much effort was expended in measuring ambient noise both in the MIZ and under continuous ice cover. Significant advances have been made in relating the observed noise to generation processes such as floe-floe interaction in the MIZ and ice ridging in the central Arctic.

Clearly data analysis is still in progress. With these new observations we are now able to more fully test existing models and formulate new hypotheses. With more than 100 CEAREX-related papers scheduled for publication in refereed journals over the next several years, we anticipate many more exciting results.

## Publications

Readers may obtain further information on some of the research described in this article from the following publications:

*CEAREX Drift Experiment*, by CEAREX Drift Group: EOS, vol. 71, no. 40, 1990.

*CEAREX Ambient Noise Data Measured Northeast of Svalbard*, by J.D. Cousins: Naval Postgraduate School, Ph.D. thesis, 1991.

*Ice Flexure Forced by Internal Wave Packets in the Arctic Ocean*, by P.V. Czipott, W.N. Podney, M.D. Levine, D. Menemenlis and R. G. Williams: Science, in press, 1991.

*The Anatomy of a Freezing Lead*, by A.J. Gow, D.A. Meese, D.K. Perovich and W.B. Tucker III: Journal of Geophysical Research, vol. 95, no. 18, p. 221–232, 1990.

*Sea-ice Modelling*, by J.M.N. Gray: University of Cambridge, Ph.D. thesis, 1991.

*A Dynamic Thermodynamic Sea Ice Model*, by W.D. Hibler III: Journal of Physical Oceanography, vol. 9, p. 815–846, 1979.

*Anomalous Diurnal Tidal Currents on the Yermak Plateau*, by K. Hunkins: Journal of Marine Research, vol. 44, p. 51–69, 1986.

*Eddy-Related Winter Convection in the Boreas Basin*, by O.M. Johannessen, S. Sandven and J.A. Johannessen: Deep Convection and Deep-Water Formation in the Oceans (J.C. Gascard and P.-C. Chu, Ed.). Elsevier, 1991.

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*Large-Scale Heat Exchange and Ice Production in the Central Arctic*, by G.A. Maykut: Journal of Geophysical Research, vol. 87, p. 7971–7984, 1982.

*Forced Convection in the Upper Ocean Near Fram Strait in Late Winter*, by M.G. McPhee: Deep Convection and Deep-Water Formation in the Oceans (J.C. Gascard and P.-C. Chu, Ed.). Elsevier, 1991.

*Mesoscale Phenomena in the Polar Oceans*, by R.D. Muench: Polar Oceanography, Part A (W.M. Smith, Ed.). Academic Press, San Diego, 1990.

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*Eastern Arctic Ambient Noise*, by R.S. Pritchard: Oceans 89, IEEE pub. 89CH2780-5, New York, vol. 4, p. 1246–1251, 1989.

*Sea-Ice Noise Generating Processes*, by R.S. Pritchard: Journal of the Acoustical Society of America, vol. 88, no. 6, p. 2830–2842, 1990.

*Wave-Ice Interaction in the Marginal Ice Zone*, by P. Rottier: University of Cambridge, Ph.D. thesis, 1991.

*Importance of Phaeocystis Blooms in the High-Latitude Ocean Carbon Cycle*, by W.O. Smith, L.A. Codispoti, D.M. Nelson, T. Manley, E.J. Buskey, H.J. Niebauer and G.N. Cota: Nature, in press, 1991.

*The Coordinated Eastern Arctic Experiment: SPRI Sea-Ice Studies*, by R.G. Williams, N.R. Davis and S.C. Moore: Polar Record, vol. 26, no. 158, p. 203–210, 1990.

Preparation for deploying oceanographic profiling sensors from Alpha Floe.



# Arctic Gas and Aerosol Sampling Program

## Highlights

RUSSELL SCHNELL

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The Arctic Gas and Aerosol Sampling Program (AGASP) is a multifaceted, multinational, cooperative research program designed to determine the distribution, transport, chemistry, aerosol physics and radiative effects of the polar-wide air pollution phenomenon known as Arctic haze. The program was organized by scientists from the Cooperative Institute for Research in Environmental Sciences (CIRES), University of Colorado, Boulder, and cooperating national and international groups. There is no overall governmental agency responsible for AGASP. AGASP has involved participants from the United States, Canada, Norway, Sweden, the Federal Republic of Germany, Australia and Denmark, and it has covered three intensive field study periods during March–April in 1983, 1986 and 1989. The core field research program consists of airborne measurements tied to similar continuous baseline station measurements at Point Barrow, Alaska; Alert, Northwest Territories (NWT); and Ny Alesund, Spitzbergen.

The results of the 1983 program were published in special issues of *Geophysical Research*

*Letters* (vol. 11, no. 5, 1984) and *Atmospheric Environment* (vol. 19, no. 12, 1985); the results of the 1986 program were published in *Atmospheric Environment* (vol. 9, no. 1–3, 1988 and vol. 23, no. 11, 1989). Papers from the 1989 program will appear in *Atmospheric Environment* in late 1991 or early 1992.

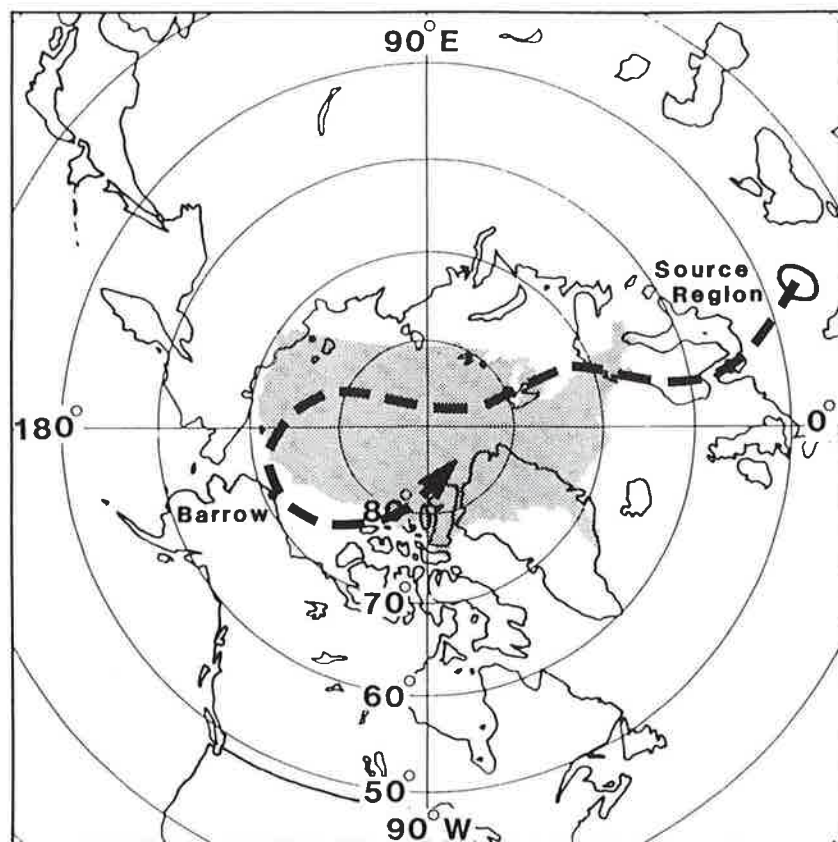
A number of scientific highlights from the overall AGASP research program and an outline of plans for AGASP-IV, March–April 1992, are presented below.

## Arctic Haze

Aircraft measurements in AGASP have shown that the haze is distributed in multiple layers from just above the Arctic surface inversion up to 8 km. The potentially great number of these layers and their sharp horizontal boundaries have been defined through airborne lidar measurements. The 25+ anthropogenic haze layer gradations had to have traveled at least 8000 km, the nearest distance to upwind sources. This well-defined structure of haze layers maintained over long travel distances is now an accepted feature of Arctic haze. Elevated concentrations of carbon dioxide, methane and carbon monoxide in these layers have been observed recently.

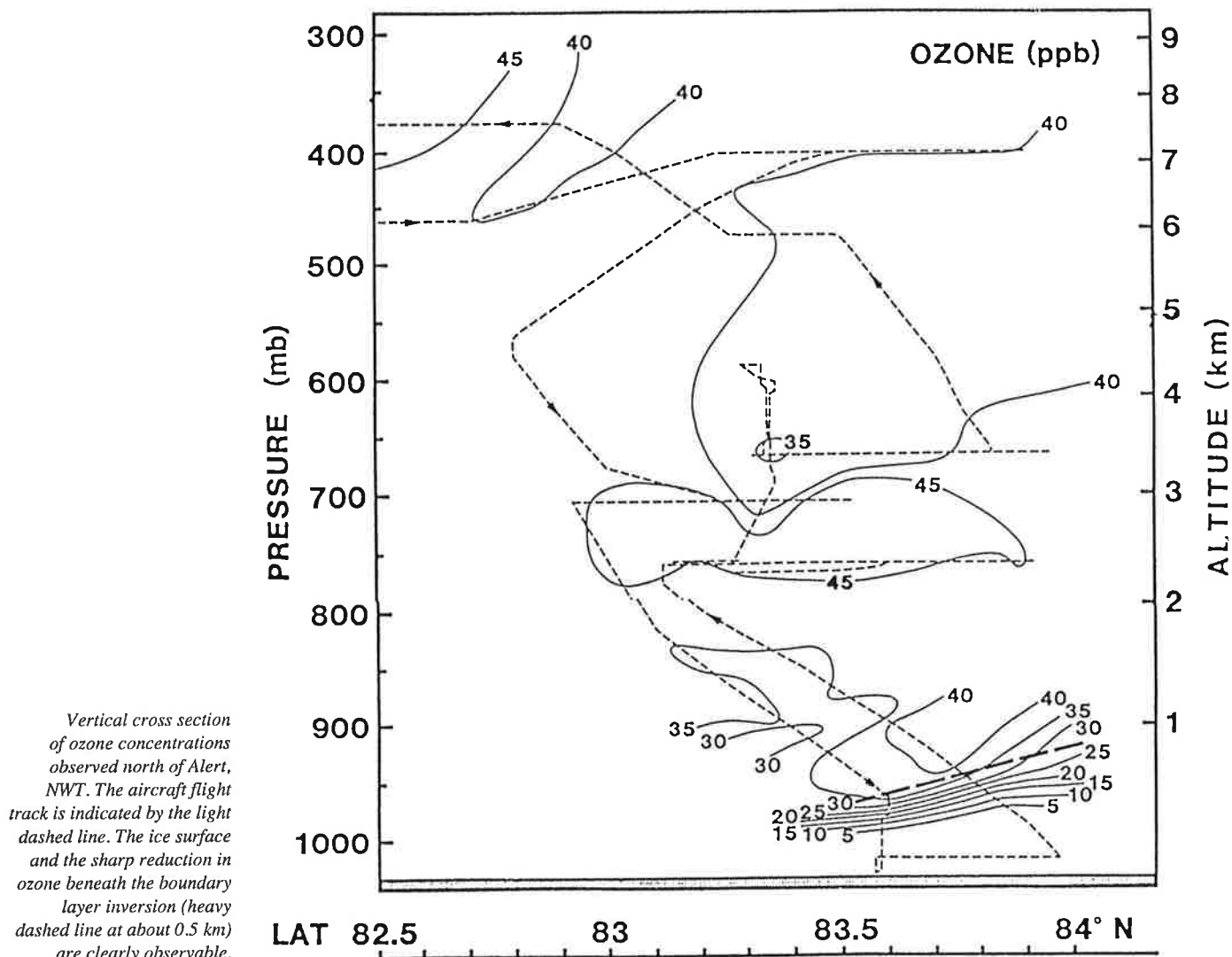
The observation of anthropogenic air pollution in the Arctic Basin attests to the fact that it is subject to long-range transport. During AGASP-II, one air pollution injection to the Arctic was sampled from European ground stations, monitored with airborne measurements within the Arctic Basin and tracked with lidar for more than 10,000 km. From its origins in Eastern Europe, it flowed across Scandinavia and north past the Norwegian monitoring station at Ny Alesund. The plume was then intercepted in the Arctic Basin with the NOAA WP-3D aircraft and tracked past Barrow, Alaska, before it flowed across the Canadian Archipelago. This haze event was last observed by ground-based lidar as it flowed east over Alert, NWT. Off Barrow the plume had condensation nucleus concentrations in excess of  $10,000/\text{cm}^3$ , soot carbon concentrations of up to  $600 \text{ ng}/\text{m}^3$  and sulfur dioxide concentrations in the range of 2–9 ppb. This event was described in detail by Bridgman et al. (1989), with a caution on Arctic air trajectory interpretation presented by Kahl (1991).

*Path of an Arctic haze event tracked from its origins in Eastern Europe across Scandinavia and over the Arctic Basin to North America. The plume traveled more than 10,000 km and was last observed heading east, off Alert, NWT. The overlay of the United States is on the same scale as the polar projection base map.*





1900-2346 GMT 14 APR 1986



## Ozone Destruction in the Arctic Boundary Layer

Early in the AGASP flight series it was observed that ozone was depleted or nonexistent beneath the lowest temperature inversion above the Arctic sea ice surface. This ozone-void region extended from the surface to at least 300 m and on occasion up to 2000 m above ice level, depending on the atmospheric temperature structure (see Kahl 1990 and Kahl et al. 1991 for Arctic temperature inversion statistics). This ozone depletion phenomenon has been shown to be the result of a photolytic reaction between bromine gas and ozone now driven by springtime sunlight. The bromine is now believed to be produced by under-ice marine algae that bloom in early Arctic spring.

In an interesting spinoff from these findings, follow-on research looking for the same phenom-

enon in Antarctica has identified a similar spring-time photolytic ozone destruction cycle. In the Antarctic, though, a decreasing trend has been observed in the absolute tropospheric ozone concentrations measured at the South Pole. The trend began in about 1980. These steadily decreasing surface ozone concentrations (17% in 10 years) are associated with a dramatic 28% increase in South Pole cloudiness, which also began in 1980.

## Detecting Ice Leads With Lidar

An exciting offshoot of airborne haze lidar research on Arctic haze has been the finding that airborne 1.06- $\mu$ m lidar can detect plumes of vapor (i.e. ice crystals) rising from open leads (cracks in the Arctic ice pack) and can sense recently refrozen

leads. This detection of open and refrozen leads in real time with an airborne instrument has the potential of assisting in the study of the energy balance in the Arctic Basin. Further information on this technique was published by Schnell et al. (1989) and Andreas et al. (1990).

## AGASP-IV

Scientists from CIRES, NOAA, NASA, the Naval Postgraduate School and 11 universities, as well as scientists from Canadian, Norwegian and German research agencies, are actively planning a major aircraft-based and baseline-station-based research program for the spring of 1992 as part of the Lead Experiment (LEADEx)/AGASP-IV field program. In broadest terms the objectives of the LEADEx program are to understand, for winter leads in the central Arctic:

- The dynamics of the coupled atmospheric-oceanic boundary layers, including local ice production processes;
- The relationship and scale dependence between external stress fields and the deformation and fracture of ice; and
- The net effect of leads on regional atmospheric and oceanic properties.

In addition to the core AGASP objectives, AGASP scientists will be involved in surface measurements from the Office of Naval Research ice station to be situated some 200 km north off the Alaskan coast and an associated NOAA WP-3D and University of Washington C-131 airborne program to determine energy fluxes from leads and to study the synoptic-scale aspects of lead-atmosphere-ice interactions. The NOAA WP-3D will be based in Anchorage, Alaska, and the C-131 in Barrow, Alaska, for the one-month (March–April 1992) aircraft program.

## Publications

Readers may obtain further information on some of the research described in this article from the following publications:

*Lidar-derived particle concentration in plumes from Arctic leads*, by E.L. Andreas, M.W. Miles, R.G. Barry and R.C. Schnell: *Annals of Glaciology*, vol. 14, p. 9–12, 1990.

*Ozone destruction and photochemical reactions at polar sunrise in the lower Arctic atmosphere*, by L.A. Barrie, J.W. Bottenheim, R.C. Schnell, P.J. Crutzen and R.A. Rasmussen: *Nature*, vol. 334,

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*Correlations among atmospheric CO<sub>2</sub>, CH<sub>4</sub> and CO in the Arctic*, by T.J. Conway, L.P. Steele and P.C. Novelli: Submitted, Arctic haze issue of *Atmospheric Environment*, 1991.

*Characteristics of the low-level temperature inversion along the Alaskan Arctic coast*, by J.D. Kahl: *International Journal of Climatology*, vol. 10, p. 537–548, 1990.

*Tropospheric low-level temperature inversions in the Canadian Arctic*, by J.D. Kahl, M.C. Serreze and R.C. Schnell: Submitted, *Atmosphere–Ocean*, 1991.

*A cautionary note on the use of air trajectories in interpreting Arctic air chemistry measurements*, by J.H. Kahl. Submitted, Arctic haze issue of *Atmospheric Environment*, 1991.

*Arctic boundary layer ozone variations associated with nitrate, bromine and meteorology: A case study*, by S.-M. Li, J.W. Winchester, J.D. Kahl, S.J. Oltmans, R.C. Schnell and P.J. Sheridan: *Journal of Geophysical Research*, vol. 95, p. 22,433–22,440, 1990.

*Aerosol and lidar measurements of hazes in mid-latitude and polar air masses*, by L.F. Radke, C.A. Brock, J.H. Lyons, P.V. Hobbs and R.C. Schnell: *Atmospheric Environment*, vol. 23, p. 2417–2430, 1989.

*Lidar detection of leads in Arctic sea ice*, by R.C. Schnell, R.G. Barry, M.W. Miles, E.L. Andreas, L.F. Radke, C.A. Brock, M.P. McCormick and J.L. Moore: *Nature*, vol. 239, p. 530–532, 1989.

*Decrease of summer tropospheric ozone concentrations in Antarctica*, by R.C. Schnell, S.C. Liu, S.J. Oltmans, R.S. Stone, D.J. Hofmann, E.G. Dutton, T. Deshler, W.T. Sturges, J.W. Harder, S.D. Sewell, M. Trainer and J.M. Harris: *Nature*, vol. 351, p. 726–729, 1991.

*Chemical and meteorological influences on surface ozone destruction at Barrow, Alaska, during spring 1989*, by W.T. Sturges, R.C. Schnell, S. Landsberger, S.J. Oltmans, J.M. Harris and S.-M. Li. Submitted, Arctic haze issue of *Atmospheric Environment*, 1991.

*Bromoalkane production by Antarctic ice algae: A potential source of surface ozone-depleting bromine radicals*, by W.T. Sturges, C.W. Sullivan, R.C. Schnell, L.E. Heidt, W.H. Pollock and D.J. Hofmann. Submitted, Arctic haze issue of *Atmospheric Environment*, 1991.

# *The Arctic Research Consortium of the United States*

## *Creating A Synergy for the Arctic*

LAURA LEE McCAULEY

Since the passage of the Arctic Research and Policy Act in 1984, the Interagency Arctic Research Policy Committee, the Polar Research Board, the U.S. Arctic Research Commission and other advisory or coordinating bodies have defined key research problems and opportunities, set broad priorities and determined some general logistical requirements for Arctic research in the 1990s. Contributing to these priorities are the recognized linkages between Arctic and global systems, the opening of political borders, the development of new technologies and the attention to principles of sustainable development and environmental protection.

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*Synergy: The simultaneous action of separate entities that together have a greater total effect than the sum of their individual effects*

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High in priority among the challenges facing the Nation and the Arctic is the problem of global change, on which national and international attention is now focused. Efforts to document and understand global change include special attention to those sensitive regions of the globe, such as the Arctic, where anticipated changes may be greatest and where changing processes will have global consequences. In fact, the Arctic provides a unique opportunity to take a regional approach to global change: to address the complex issues of transferring information across large spatial and temporal scales, to integrate knowledge from diverse disciplines such as the social sciences with the natural sciences, and to provide advanced understanding of polar processes for use in improving global circulation models.

In addition to global change research, there are other problems and opportunities for the Arctic research community. For example, improved understanding of how to manipulate plant and animal genetic systems may make it possible to advance agricultural productivity, human habitability and economic sustainability. Enhanced engineering research in the Arctic has broad implications for energy conservation, materials development and operational capabilities in remote regions. The Arctic is also a laboratory unto itself—a “test bed” for policy in resource management, environmental

conservation, societal integration and international cooperation.

However, because “Arctic science” does not denote a discipline but rather a multidisciplinary pursuit of knowledge about an area, it does not meet the generally accepted criteria for establishment of academic departments. Except for a handful of mostly university-based research organizations, there are no academic departments that maintain curricula for the education of new scientists who will focus specifically on Arctic problems. Moreover, there are no focal points to provide exposure, guidance and information on short-term and long-term research opportunities for students and others; nor have there been sustained efforts to facilitate collaboration among members of the existing Arctic research community. This, along with the geographical nature of the area, has resulted in a dispersed community and the risk that there may be few new researchers to carry on existing research and to address the new challenges posed by global change.

Indeed, the Arctic is too vast and complex for any one institution to address all of these concerns alone. For the U.S. to provide leadership in scientific investigations in the Arctic, an infrastructure that would coalesce the Arctic academic and research community was needed. The Arctic Research Consortium of the United States (ARCUS) was formed to meet this need. Designed to identify and bring together the distributed human and facilities resources of the community, ARCUS is endeavoring to create a synergy for the Arctic—a climate in which each resource, when combined with others, can result in a strength that enables the community to rise to the many challenges facing the Arctic and the United States.

The concept of an Arctic Research Consortium was discussed by the Arctic research community for many years. This discussion became more focused following the passage of the Arctic Research and Policy Act and the subsequent establishment of the U.S. Arctic Research Commission (USARC) and the Interagency Arctic Research Policy Committee (IARPC). In January 1988, representatives of a dozen institutions met in Boulder, Colorado, to begin organizing a research consortium of institutions with strong interests in Arctic studies. On 9 October 1988, ARCUS was officially inaugurated, with the primary mission of

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strengthening Arctic research to meet national needs. ARCUS was formed to serve, in part, as an academic contributor, discussant and advocate, as well as to provide an implementation mechanism for the Arctic community to complement the roles of the USARC, IARPC and the Polar Research Board.

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## *ARCUS will initially focus on two issues: the role of the Arctic in global change and the requirements for a national Arctic education program*

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Specifically the purpose of ARCUS is to provide leadership in advancing knowledge and understanding of the Arctic by:

- Serving as a forum for planning, facilitating, coordinating and implementing disciplinary and interdisciplinary studies of the Arctic;
- Acting as a synthesizer and disseminator of scientific information relevant to state, national and international programs of Arctic research; and
- Encouraging and facilitating the education of scientists and the public in the needs and opportunities of research in the Arctic.

ARCUS consists of institutions organized and operated for educational, professional or scientific purposes. An institution is considered eligible for membership in ARCUS if it has made a definitive, substantial and continuing commitment to a coherent research program or course of studies leading to degrees in one or more disciplines associated with Arctic research or related fields. Today ARCUS has 19 voting-member institutions from 14 states, as well as three nonvoting international affiliates. The members' representatives constitute the Council of ARCUS and elect the Board of Directors. Together and with other colleagues they have identified three primary long-term goals:

- *To produce identifiable improvements in U.S. Arctic science*

The importance of the Arctic, to the Nation and internationally, requires a consensus of the Arctic research community on pertinent issues and research needs, the transfer and application of cold regions research and technology to meet national and industry needs, increased levels of funding for Arctic science by Federal, state and local governments, and improvements in the level of cooperation between the U.S. and international Arctic research institutions and industries.

- *To build Arctic research communities of scientists and scholars in the U.S.*

New and highly qualified scientists and engineers must be educated and trained in the critical

scientific, economic and engineering skills required to address the strategic problems of the Arctic. In addition, the need for an expanded social science research program on Arctic topics will require a well-organized and cohesive community of social and behavioral scientists that are interested in the Arctic.

- *To open avenues for interdisciplinary approaches, the introduction of new techniques and the widening of scientific participation*

Arctic research problems are often complex and require interdisciplinary approaches. Gathering specialists, however, is not enough. To analyze complex systems, researchers must cross disciplinary boundaries. This step often leads to the development of new techniques and opens the door to new solutions. Increasing communication among different Arctic disciplines and science communities is one key to developing Arctic science. The dispersed nature of the Arctic research community, however, remains an impediment to optimal cooperation across disciplines. ARCUS recognizes the need to create bridges across a distributed set of institutions and to create mechanisms whereby scientists from all disciplines and geographical regions can access the Arctic and contribute to the scientific agenda.

## *Current Activities*

Given the long-term goals for ARCUS as established by the members, two issues were chosen for the consortium to focus on initially: the role of the Arctic in global change and the requirements for a national Arctic education program. It was felt that efforts in these two areas would be inherently complementary. Moreover, both would serve to coalesce the community because they cut across the disciplines of Arctic science. They would also provide a mechanism for determining current strengths within the community and areas of need.

### *The Role of the Arctic in Global Change*

In the mid-1980s, evidence of sensitivity and change in high latitudes led to a number of proposals from the USARC and the Polar Research Board for an increased emphasis on scientific research in the Arctic. Other proposals included the National Aeronautics and Space Administration (NASA) Global Tropospheric Experiment to study atmosphere-biosphere interactions in boreal and Arctic regions of North America; a call for an Arctic component of the International Geosphere-

#### *MEMBER INSTITUTIONS*

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Biosphere Programme (IGBP), developed by the Royal Society of Canada; and new elements of Arctic research that were proposed in Global Geosciences and the program for Long-Term Ecological Research of the National Science Foundation (NSF).

In 1987 two international workshops were held by the Office for Interdisciplinary Earth Studies of the University Corporation for Atmospheric Research to build on these and other studies. The report of these workshops, *Arctic Interactions*, outlined a program of Arctic research for emphasis in the IGBP. This report concentrated on a selected number of front-line questions in interdisciplinary Arctic science whose answers were likely to provide fundamental knowledge that would serve as a basis for assessing likely global changes in the next hundred years.

Building on these initiatives from the science community, a new program called Arctic System Science (ARCSS) was initiated at NSF as part of their contribution to the U.S. Global Change Research Program. The goal of the ARCSS program, as determined by the community through the organizational efforts of ARCUS, is two-fold:

- To understand the physical, chemical, biological and social processes of the Arctic system that interact with the total Earth system and thus contribute to or are influenced by global change; and
- To advance the scientific basis for predicting environmental change on a decade-to-centuries time scale and for formulating policy options in response to the anticipated impacts of changing climate on humans and societal support systems.

The NSF ARCSS program is made up of three components with staggered start dates: paleoenvironmental studies, ocean-atmosphere-ice interaction studies and land-atmosphere-ice interaction studies. The paleoenvironmental studies compo-

nent of ARCSS is addressed through two initiatives: the Greenland Ice Sheet Project (GISP) and the Paleoclimates of Arctic Lakes and Estuaries (PALE) initiative.

Underway since 1989, GISP is retrieving a deep ice core from central Greenland. The 3,000-m-deep GISP core will yield a high-resolution, 200,000-year history of global change, including two interglacial and two glacial cycles, the longest such record available from the Northern Hemisphere. Signals that are generated by interactions within the global system are "captured" in the ice sheet and are available for viewing by sophisticated analyses of ice cores. Such studies will significantly advance current understanding of global change—evolution, process, trend and coherence—and provide the type of perspective necessary to assess predictive global change models. Specifically the GISP core will yield:

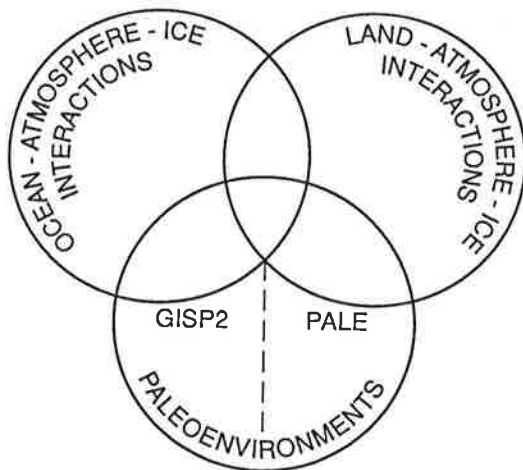
- High-resolution views of Holocene and pre-Holocene climate and atmospheric chemistry;
- Documentation of the partitioning, reservoir exchange and production rates for anthropogenic, volcanic, biogenic, oceanic, terrestrial and cosmogenic sources of the gaseous constituents in the atmosphere;
- Determination of the relationship between timing and forcing as revealed by comparisons of climate, radiatively important gases and aerosols, biogeochemical cycling and other system boundaries; and
- Development of accurate dating techniques and flow modeling for pre-Holocene ice.

Paul Mayewski, director of the GISP Science Management Office (Institute for the Study of Earth, Oceans, and Space, University of New Hampshire, Durham, NH 03824-3525) can be contacted for more information regarding the objectives and activities of GISP.

Important elements of PALE, the newest initiative under the paleoenvironmental studies component, were determined at a workshop organized and hosted by the University of Colorado in March 1991. They include a circumpolar perspective of Arctic climate change, the use of multiparameter core analyses, careful chronological control and an assessment of feedbacks within the global climate system. Three key questions have been identified for PALE:

- What is the evidence of climate variations in the Arctic over the past 1000 years? In particular, is there evidence in lake and estuarine environments for the Medieval Warm Period and Little Ice Age? How did the magnitude, timing and geographic extent of these events in the Arctic relate to those from other latitudes?

The three components of the ARCSS program



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- What are the regional patterns of Arctic climate change during the late Quaternary and what large-scale climatic controls have governed these patterns? What are the circumpolar patterns in important features of late-Quaternary climate such as the glacial-deglacial transition, the local Holocene thermal maximum and the onset of late-Holocene cooling?
- What were the characteristics and regional patterns of previous glacial-interglacial cycles? For example, did the greater summer insolation at 126,000 BP result in warmer summer climates than occurred during the Holocene? To what extent do positive feedbacks in the Arctic climate system reinforce the effects of insolation maxima? Are the characteristics of major climatic warming at glacial-interglacial transitions similar for different cycles?

The co-chairs of the PALE science steering committee are John Andrews, Institute of Arctic and Alpine Research (INSTAAR) at the University of Colorado-Boulder (Boulder, CO 80309-0450), and Linda Brubaker, College of Forest Resources, University of Washington (Seattle, WA 98195).

The key questions that the ocean-atmosphere-ice interactions (OAI) component will address were identified at a workshop organized by the Joint Oceanographic Institutions Incorporated (JOI) and held at the University of California, Los Angeles, Lake Arrowhead Conference Center in March 1990. They are:

- How do interactions among the Arctic Ocean, its sea ice cover and the overlying atmosphere influence and respond to the state of the global climate system? Interactions and feedbacks among the components of this system play a key role in model-predicted distributions of greenhouse warming over the Northern Hemisphere but are based on poorly known model parameters. New measurements on sea ice thickness and distribution, ocean circulation, cloudiness, radiation and snow cover are needed, and these must be integrated with new models of global-Arctic interactions.
- How are freshwater, ice and other tracers transported and transformed in the Arctic Ocean? Small changes in the Arctic Ocean's input to the North Atlantic Ocean could shut off the deep water formation that drives the thermohaline circulation of the Atlantic. An improved understanding of the hydrologic cycle and freshwater balance of the Arctic Basin, including precipitation, river runoff, ocean circulation and mixing, sea ice and the synthesis of these results, is required.
- How will the ecosystems of the Arctic Ocean

and its adjacent seas change during the next 100 years and what will be the effects of these changes? The seasonal cycle of productivity is the basis for a complex food web; variations in the web may have implications far beyond the Arctic. New measurements and process studies are needed to understand this system and to provide the basis for predicting its response to global warming.

- How did the ice cover, stratification, circulation and productivity of the Arctic Ocean vary in the past? Millions of years ago the Arctic Ocean was ice free. Is this an analog for future high-carbon-dioxide climates? A thorough study of existing Arctic sediment cores, from the shelves, slopes and deep basins, is needed for synthesizing a paleoclimatic history of the Arctic Ocean and its marginal seas and for guiding the acquisition of new cores to fill important gaps in this history.

Richard Moritz, Applied Physics Laboratory of the University of Washington (Seattle, WA 98105-6698), chairs the OAI science steering committee and can be contacted for more information.

The last component of the NSF ARCSS program to be initiated, land-atmosphere-ice interactions (LAI), seeks to enhance understanding of these interactions in the Arctic system, the role these processes play in the whole Earth system and the effect that global change may have on the Arctic. Four critical research questions have been identified:

- How will feedback processes within the Arctic system amplify global climate change? What is the variability of climate on different time and space scales and what are the mechanisms that control the variability? What polar feedback processes are important in affecting global climate change and what studies need to be undertaken to understand these feedback processes better? What improvements need to be made to numerical climate models in the treatment of polar processes to serve both regional and global-scale needs?
- What changes will occur in Arctic hydrologic and biogeochemical systems and what will be their effects? How do changes in water-ice content and temperature in Arctic soils, and other external forcings, affect the biologic processes that cause uptake or release of greenhouse gases? How will changes in the fluxes of water and water-borne nutrients and other materials affect the Arctic ecosystem? What are the interactions between snow cover and regional and global change and how do changes in snow cover affect the Arctic system?
- What changes will occur in Arctic plant and

animal communities and ecosystems and what will be their effects? What will be the rate of change of Arctic plant and animal communities? What will be the important changes in ecosystem function as a result of changes in community composition? How will trophic interactions and structure change as a result of community change?

- How will changes in the Arctic system affect and be affected by human action? How will residents in the Arctic respond to environmental changes and will these responses amplify or dampen changes in the land-atmosphere-ice system? How have past human societies in the north reacted to long-term and short-term climate fluctuations and alterations in political and economic linkages to the south? What are the principal anthropogenic forces originating outside the Arctic that are likely to lead to large-scale changes in the Arctic?

The objectives of the LAII component of ARCSS were determined at a workshop held in March 1990 that was organized by ARCUS and hosted by INSTAAR in Boulder. For more information, please contact Mark Meier of INSTAAR, University of Colorado (Boulder, CO 80309-0450).

One of the major goals of the ARCSS program as a whole is the prediction of changes using interactive models of the Arctic system such as a series of mesoscale (regional) models, with a horizontal resolution of 10–100 km, that incorporate realistic treatments of processes and interactions on all important scales. For several Arctic processes there

winds and temperatures as time-varying lateral boundary conditions. In turn the regional models would incorporate the building blocks of hydrologic, biogeochemical or biogeophysical models on landscape or smaller scales. In this way the regional models would bridge the gap in scales between atmospheric GCMs and land-surface process models.

The paucity of data on Arctic processes makes data collection an essential first step. Data collection must be carried out in conjunction with the development of this hierarchy of mathematical or numerical models at their varying degrees of complexity.

Requirements critical to the implementation of the NSF ARCSS program, as identified by the participants of the many planning meetings, include:

- A U.S.-flag research vessel capable of carrying out physical, biological and chemical oceanographic research in the ice-covered central Arctic Ocean during all seasons;
- New terrestrial sites, and transects of sites, for intensive interdisciplinary research;
- A centralized logistical information and coordination facility;
- Coordinated experiments and campaigns of extensive, simultaneous measurements at the surface, from the air and in conjunction with satellite overpasses; and
- Expansion and continuation of existing monitoring and measurement programs.

Other issues raised during the planning sessions included the need for multiagency as well as multinational participation. Clearly the National Science Foundation's leadership and support for the ARCSS program has allowed the community to begin planning and implementing many aspects of the basic research program. But a focused, systems-science research endeavor as proposed by the Arctic research community will require the capability and expertise of other Federal science agencies, consistent with their individual mandates and charters. Through the activities of the IARPC a number of ongoing or planned research programs relevant to the goals of Arctic System Science have been identified. An established mechanism, perhaps within the IARPC or the Committee on Earth and Environmental Sciences of the White House Office of Science and Technology Policy, to link these activities and to facilitate multiagency involvement in, and commitment to, a program of Arctic System Science, is essential for its success. Last December at a multiagency briefing in Washington, D.C., organized by ARCUS and co-sponsored by JOI, the research community presented their findings and recommendations for an ARCSS program, highlighting the need for a coor-

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### *The paucity of data on Arctic processes makes data collection an essential first step*

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are large gaps between state-of-the-art formulations and their treatment (or even inclusion) in atmospheric general circulation and other global models. In some cases, such as the surface energy balance, the models are very sensitive to the formulation that is used. An important aspect of this research is the problem of scaling: the aggregation of small-scale processes that are important in shaping the large-scale interactions and the disaggregation of large-scale model results for application to sites or small landscape units. Thus, these regional models would not stand alone nor would they be used independently for long integrations of climate change. Rather the regional models would be nested in and fully interactive with coarse-resolution, global general circulation models (GCMs) or would use GCM results such as

minated and consolidated approach to research in the Arctic.

Studies of the entire Arctic system, which encompasses large land areas in North America, Europe and Asia, as well as the Arctic Ocean and its peripheral seas, obviously require international collaboration. While many bilateral efforts in coordinating research have been underway for years, much remains to be done in bringing together all or most of the nations doing research in the Arctic. This is especially urgent for U.S. researchers, who are severely limited by the lack of icebreaking research vessels and by a need to work with other nations (Canada, Greenland and the European Arctic) for access to high-Arctic terrestrial systems.

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*Studies of the entire Arctic system, which encompasses large land areas in North America, Europe and Asia, as well as the Arctic Ocean and its peripheral seas, obviously require international collaboration*

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A window of opportunity has been created for a circumpolar research effort in the Arctic. Through the establishment of the nongovernmental International Arctic Science Committee (IASC) in January 1991, new possibilities for coordinating and implementing Arctic research now exist. All the nations with major research programs in the Arctic (14 in all) are members of IASC. A working group on global change research has been established and will work on an implementation strategy for this broad topic. A regional program for the entire Arctic, under the auspices of the International Geosphere-Biosphere Programme (IGBP), may well develop from this effort. In a recent report of the IGBP entitled *Global Change System for Analysis, Research and Training (START)*, the Arctic region is listed as one of 14 regions in which a regional research network should be sited. The World Climate Research Programme (WCRP) is working on an international climate study called ACSYS (Arctic Climate System Study), which is primarily concerned with Arctic freshwater and ice balances.

Other international efforts are underway. A predictive understanding of the Arctic system will be impossible without a truly pan-Arctic global change research effort; thus, continued U.S. support and participation within IASC is an important first step toward developing such a coordinated effort.

All planning activities to date have been carried out by either workshop organizing committees or more formal science steering committees. As these groups continue refining science plans specific to their respective research component, ARCUS will,

with NSF sponsorship, convene a panel to integrate these plans into one comprehensive implementation strategy for the ARCSS program as a whole, in keeping with the system-science focus. This process will provide an opportunity to address some of the issues and opportunities presented by ARCSS, such as integration of the sciences, an ARCSS data management program, a coordinated and efficient logistics capability, multiagency involvement and commitment, and international collaboration. This panel will be made up of representatives from the steering committees as well as other individuals whose expertise and experience will facilitate the panel's work.

Of course, a substantial increase in funding is imperative if the goals of the ARCSS program are to be realized. Though the National Science Foundation, to its credit, has made every effort to increase the funding available for Arctic research, the slow growth does not allow the community to take advantage of the accumulated base of knowledge and recent technological developments and move forward with sufficient speed to tackle these aspects of the national research agenda. At the invitation of the Honorable John Kerry, Senator from Massachusetts, ARCUS, along with the ARC, IARPC and the Polar Research Board, presented testimony in April to the Subcommittee on National Ocean Policy of the Senate Committee on Commerce, Science and Transportation emphasizing the readiness of the Arctic research community to implement an aggressive science program that will advance the scientific basis for predicting global change.

### *Requirements for a National Arctic Education Program*

As a result of growing scientific and international interest in global change and other research areas, momentum is building toward a new era of Arctic research. The challenge is to convert this momentum into the reality of fully developed and internationally recognized research endeavors. Essential to their success will be the development of human resources—teams of scientists and engineers—to carry out these efforts. Over the past year ARCUS has been developing a strategy for addressing this need. The objectives laid out in the prospectus for “An Initiative in Education” are:

- To ensure that high-quality information and education in Arctic science are available to the general public, students and teachers, and Natives of the Arctic;
- To enable interested and talented students to pursue scientific careers in the Arctic; and



- To ensure that the work force exists to meet the challenge of the national Arctic research agenda.

The initiative targets a broad spectrum of needs: public awareness and education, Native education and involvement, K-12 science teacher education, and undergraduate and graduate programs.

We anticipate that a three-phase effort will be required to do a systematic and thorough job: phase 1, assessing the status of the Nation's Arctic education and research capability; phase 2, designing and developing mechanisms and activities to ensure an effective and efficient comprehensive education program; and phase 3, implementing and evaluating these initiatives.

Even though we perceive a need for more scientists to address Arctic research problems and education programs to facilitate this, we lack specifics on the scope of the problem and the activities that would serve to address it. Therefore, it is important to ascertain the actual state of Arctic education and research today. We know, for instance, that there are numerous independent educational activities overseen by various individuals in the community: What are they and what are their goals? Are they effective and meeting their objectives? What happens to students who participate in them? What job opportunities await new students? Would linkages among these programs help? What is the current state of the Arctic research community? What resources, such as expertise, facilities and equipment, are currently available?

The activities of phase 1 will involve defining educational requirements unique to the Arctic, developing surveys and questionnaires, determining appropriate recipients, and compiling and synthesizing the information in an accessible format for review by the community. Along with providing the information base to clarify needs, these activities will begin the process of building the community and a network to facilitate their interaction. Surveys will seek information on:

- Current curricula and established local and national education programs in all disciplines of Arctic science;
- Student interest and participation in northern study programs around the Nation;
- Individual Arctic faculty (academic and affiliates) and researchers; and
- Relevant research and education facilities.

Phase 2 involves planning how existing programs may be drawn into a cooperative network of Arctic educational programs, and identifying new initiatives to fill in gaps in the current offerings. To aid the process of identifying activities and

components that are important to any comprehensive, effective and efficient education program, we will use the following tentative list of program components as a preliminary checklist:

- A clearinghouse for information;
- A national and rural Arctic guest lecture program;
- Seminars for science writers;
- Public television shows;
- Museum exhibits;
- Curriculum development;
- Long-distance delivery programs for rural Arctic communities;
- A minor in northern studies;
- Off-campus experiences and classes;
- Networks through which students and faculty can interact;
- A nationwide conference on the Arctic for students;
- Research assistantships, internships and fellowships for studies and participation in state and national research programs;
- A mechanism to provide graduate students the opportunity to study with experts in their field of interest and at various facilities, wherever they are located;
- Student and faculty exchanges; and
- Arctic science "institutes."

It is at this point that we expect to plan some qualitatively new initiatives in Arctic education. A timetable for implementation and criteria for measuring success will be important aspects of the program development phase. We expect that these new initiatives will bring the unique properties and challenges of the Arctic clearly into the field of vision of the general public.

To move expeditiously toward fulfilling the objectives of ARCUS's initiative in education, phase 2 of the effort will begin as soon as preliminary data from phase 1 begin to suggest an appropriate approach. While it is premature to formulate a definitive list of issues to be addressed, it seems probable that the following will be included:

- The actual and potential interest in Arctic studies as a field of specialization for undergraduates and graduate students;
- Effective interaction between an Arctic educational program and indigenous peoples of the far north;
- Possibilities for interaction between initiatives originating in the U.S. and those of other northern countries; and
- Possible nongovernmental sources of support for an Arctic studies program.

These activities will be guided by an Arctic Education Panel. The 23 members invited by ARCUS to join this panel come from 13 states and

Canada and include specialists in Arctic education at the primary, secondary, undergraduate and graduate levels, as well as in the natural and social sciences. The panel is co-chaired by John Andrews (INSTAAR, University of Colorado, Boulder, CO 80309-0450) and Steven Young (Center for Northern Studies, Wolcott, VT 05680). Working groups will be appointed during phase 2 to define individual components of the overall plan for Arctic education. Financial support for phases 1 and 2 is being sought from the National Science Foundation.

Along with directories resulting from the surveys, the panel will produce a "plan for action" and a small pamphlet providing a guide to Arctic education resources. All findings, suggestions and recommendations will be forwarded to members of the community for comment and input each step of the way. Progress reports will be made throughout the two phases of activities to participants at the ARCUS annual meeting, at science symposia (such as the AAAS Arctic Science Division Meeting) and in the literature.

## In the Future

During the Third Annual Meeting of ARCUS at the University of Massachusetts-Amherst in March 1991, the President, Dr. Albert Johnson of San Diego State University, challenged the members' representatives and their colleagues to look to the future. In conjunction with the efforts supporting the ARCSS program and the education initiative, they identified and prioritized additional areas where ARCUS is well positioned to undertake activities that will strengthen the community's ability to respond to Arctic research priorities more effectively and efficiently. Areas warranting special attention include the Arctic social science agenda, communication and coordination among current data and information activities and the user community, logistics and cold regions technology development activities, linkages and collaboration with ARCUS's international colleagues, and Federal understanding and commitment to the national Arctic research agenda. To focus discussions, ad hoc working groups were formed to articulate needs and suggest appropriate actions to address them. These recommendations, along with the more mundane management goals of the organization, will provide a basis for the development of ARCUS's plans for the future.

The energy, involvement and effort of the members of the community are imperative for the success of ARCUS endeavors. This dependency makes sense since its activities develop to address

needs identified by the community. As an organization committed to bringing together the distributed human and facilities resources of the community, the participation from all members of the Arctic research community in the "ARCUS dialogue" is essential; indeed, this participation may be critical in ensuring that the momentum developing nationally in support of Arctic research continues to grow. Thus, all members of the Arctic research and academic community are invited to join with ARCUS in building a synergy, a strength that enables the community to rise to the many challenges facing the Arctic and the United States.

## Publications

Readers may obtain further information on some of the activities described in this article from the following publications:

*The Role of the Polar Regions in Global Change, Proceedings of an International Conference, Fairbanks, Alaska, 11-15 June 1990*, edited by G. Weller and C. Wilson: UAF Geophysical Institute and the Center for Global Change, Fairbanks, Alaska, in press.

*Arctic System Science Land/Atmosphere/Ice Interactions: A Plan for Action*, based on a workshop, Boulder, Colorado, 26 February-3 March 1990: ARCUS, Fairbanks, Alaska, 1991.

*Paleoclimate of Arctic Lakes and Estuaries: A New NSF Initiative*, by John Andrews: EOS Transactions, vol. 72, p. 31, 1991.

*U.S. Readiness to Address the National Arctic Research Agenda*, ARCUS testimony for the Hearing on Arctic Ocean and Global Change Research before the Senate Committee on Commerce, Science and Transportation, 24 April 1991: ARCUS, Fairbanks, Alaska, 1991.

*The Increasing Importance of Arctic Research to the United States*, U.S. Arctic Research Commission testimony for the Hearing on Arctic Ocean and Global Change Research before the Senate Committee on Commerce, Science and Transportation: U.S. Arctic Research Commission, Washington, D.C., 1991.

*Priorities in Arctic Research*, National Research Council Polar Research Board testimony for the Hearing on Arctic Ocean and Global Change Research before the Senate Committee on Commerce, Science and Transportation, 24 April 1991: Polar Research Board, Washington, D.C., 1991.

*Strategy for Integrated U.S. Arctic Research Programs*, by Interagency Arctic Research Policy Committee, Washington, D.C., 1991.

*The Fourth Annual Meeting of ARCUS: A Joint Meeting with the U.S. Arctic Research Commission and the Polar Research Board will be held in Washington, D.C., on 24-25 March 1992.*

- Goals, Objectives and Priorities to Guide United States Arctic Research: Findings and Recommendations of the U.S. Arctic Research Commission*, Washington, D.C., Issue No. 7, 1991.
- Our Changing Planet: The FY 1992 U.S. Global Change Research Program, A Supplement to the U.S. President's Fiscal Year 1992 Budget*, by Committee on Earth and Environmental Sciences, Washington, D.C., 1991.
- Global Change System for Analysis, Research and Training (START), Report of a meeting at Bellagio, 3-7 December 1990*, edited by J.A. Eddy, T.F. Malone, J.J. McCarthy, and T. Rosswall: International Geosphere-Biosphere Programme, Report No. 15, Boulder, Colorado, 1991.
- Arctic System Science Ocean/Atmosphere/Ice Interactions, Report of a Workshop held at the UCLA Lake Arrowhead Conference Center, 12-16 March 1990*, edited by ARCSS OAI Workshop Steering Committee: Joint Oceanographic Institutions, Inc., Washington, D.C., 1990.
- Arctic System Science: Advancing the Scientific Basis for Predicting Global Change*, by ARCUS, Boulder, Colorado, 1990.
- The International Geosphere-Biosphere Programme: A Study of Global Change, The Initial Core Projects*, by International Geosphere-Biosphere Programme, Report No. 12, Stockholm, 1990.
- Arctic Interactions: Recommendations for an Arctic Component in the International Geosphere-Biosphere Programme, Based on Two Workshops, Boulder, Colorado, January and March 1987*, by Office for Interdisciplinary Earth Studies, University Corporation for Atmospheric Research, Report OIES-4, UCAR, Boulder, Colorado, 1988.
- United States Arctic Research Plan*, by Interagency Arctic Research Policy Committee, Washington, D.C., 1987.
- The Role of the National Science Foundation in Polar Regions—A Report to the National Science Board*, by Committee on the NSF Role in Polar Regions, National Science Board, National Science Foundation, Washington, D.C., NSB-87-128, 1987.
- Arctic Research in the National Interest*, by A.L. Washburn and Gunter Weller: Science, vol. 233, p. 633-639, 1986.
- National Issues and Research Priorities in the Arctic*, by Polar Research Board, National Research Council, Washington, D.C., 1985.
- United States Arctic Interests, The 1980s and 1990s*, edited by W.E. Westermeyer and K.M. Shusterich: Springer-Verlag, New York, 1984.
- The Polar Regions and Climatic Change*, by Committee on the Role of the Polar Regions in Climatic Change, Polar Research Board, National Research Council: National Academy Press, Washington, D.C., 1984.
- Arctic Research and Policy Act*, U.S. Congress, Public Law 98-373, 1984 (amended 1990).
- A United States Commitment to Arctic Research*, by Committee on Arctic Research Policy, Polar Research Board, National Research Council: National Academy Press, Washington, D.C., 1982.
- Arctic Systems*, edited by P.J. Amaria, A.A. Bruneau, P.A. Lapp: NATO Conference Series, Series 11, Systems Science, Vol. 2, Plenum, New York, 1977.
- Polar Research, A Survey*, by Committee on Polar Research, National Research Council: National Academy of Sciences, Washington, D.C., 1970.
- Report of the University Committee on Polar Research*, Ann Arbor, Michigan, 1961.
- Summary Report of Dartmouth Conference on Organization of Polar Research in the United States*, Dartmouth College, Hanover, New Hampshire, 18-19 December, 1958.

# *Managing the Arctic's Resources*

## *The Working Group on Arctic International Relations*

ORAN YOUNG

The Working Group on Arctic International Relations is a freestanding forum in which individuals participate in their private capacities. The Working Group seeks to foster international cooperation in the Arctic by providing early warning of emerging issues, devising innovative policy options, and serving as an informal channel for communications among the Arctic states. While the Group as such does not take public positions on specific Arctic issues, individual members are free to make unattributed use of information or insights gained from participation in the discussions of the Group. The affairs of the Working Group are entrusted to the co-chairs, who consult extensively with other members on all aspects of the Group's activities (see *Arctic Research of the United States*, Fall 1990, p. 71).

Thirteen persons drawn from seven of the eight Arctic countries came together in Alaska for the fourth session of the Working Group. The session, spanning the period 20–24 September 1990, took place in Kaktovik and Prudhoe Bay. The session addressed the theme of “managing the Arctic's resources” and devoted particular attention to opportunities for devising regimes for facilitating cooperation in managing shared resources.

Like its predecessors, this statement is not simply a record of the Working Group's discussions. Rather, it is an attempt on the part of the co-chairs to convey impressions gained from the Alaska session but fleshed out in subsequent conversations. Following immediately on the launching of the Northern Forum at the Third Northern Regions Conference in Anchorage, the Alaska session devoted particular attention to the importance of taking steps to heighten the role of northern users in forming and implementing regimes capable of managing the shared resources of the Arctic in a sustainable and equitable fashion.

### *A Matter of Perspective*

The sharing of resources among Arctic countries is both existential and purposive. It is existential when the resources in question—migratory animals, pools of oil or gas, rivers and sea routes—either pass through or are transected by accepted or contested lines demarcating some degree of national jurisdiction. There is no sharing here in the sense of international agreements governing the activities of those who use the resources. But there is sharing in fact, whether or not the parties seek

to devise equitable management arrangements, endeavor to take more than their “fair” share, or ignore problems of joint use altogether. Shared resources in the existential sense are not created; they exist by virtue of long-established or yet-to-be-established state frontiers. However, when states endeavor to cooperate in managing existential shared resources, they may be said to engage in purposive sharing. Our prime concern in this statement is with purposive as distinct from existential sharing in the circumpolar North. It is with the creation of sharing behavior under conditions of existential sharing. Joint management regimes are the prime means of promoting purposive sharing.

In thinking about purposive sharing, it is helpful to adopt an ecological perspective, which rejects the assumption that shared Arctic resources are things in themselves that lie “up there” and are to be managed from distant centers of decision. Rather, this perspective views shared resources as integral to widening patterns of social and socio-environmental interaction, which in their totality are the proper subject of management. The point of departure for an ecological definition of the problem in managing shared Arctic resources is thus one of working together in conditions of expanding interdependence. It is ultimately one of self-management in which those most directly associated with the resources in question have primacy of place both in defining the problem to be solved and in shaping the agreed action.

In its preference for self-management, the ecological perspective points to the management of human activity and human–milieu interactions as opposed to the regulation of physical assets as such. It also connotes a need to accord special responsibilities to those most directly affected by the control and use of given resources. Practitioners will therefore find it appropriate, wherever possible, to cut into what we have called the total management system at the local and subregional levels in the Arctic. In this it will of course be recognized that certain shared resource issues do not lend themselves to management by means of Arctic-wide, much less subregional, regimes. But where local or subregional responses will suffice, the ecological perspective suggests that they be sought through processes that amount to a devolution of decision-making authority to the local level.

What lessons can be drawn from an examina-

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tion of actual and ongoing efforts to create subregional management regimes for the Arctic's shared resources? Our discussions in Alaska reverted again and again to this question. Here we can only summarize some of the principal conclusions that flowed from these discussions and that strike us as particularly interesting to practitioners responsible for dealing with analogous matters in the future.

- There is much to be said for limiting the scope of resource regimes to those geographical areas, functional domains and parties actually needed to solve the problem at hand. Some issues, like the protection of birds that migrate far to the south or the control of the Eurasian sources of Arctic haze, obviously require broader management schemes. But subregional arrangements, which affected parties (including local users) can grasp and relate to without difficulty, have much to recommend them wherever they will suffice to solve the problem.
- At the same time, those involved in designing subregional resource regimes should be guided by an ecosystems approach emphasizing the protection of habitat in the case of renewable resources and the linkages tying complex physical and biological systems together in the case of pollution control. This suggests that the scope of modern resource regimes should be broader than the traditional single-species, maximum-sustainable-yield arrangements (for example, the fur seal regime). As the cases of the Bering Sea marine ecosystem and the Kola-Fennoscandia airshed demonstrate, however, this requirement is fully compatible with a strategy that emphasizes the role of subregional arrangements.
- Coordination regimes featuring common rules coupled with decentralized implementation are attractive whenever they will suffice to deal with the problems at hand. Some problems, like the emergent arrangement for the control of air pollution in the Kola Peninsula-Fennoscandia area, clearly require more elaborate forms of cooperation. But the coordination regime for polar bears works well; it offers a model of simplicity worth bearing in mind in designing management regimes for other shared resources.
- There is much to be said also for establishing regimes that are flexible enough to adapt to changing ecological and socio-economic conditions without requiring formal amendment. International resource regimes are virtually always time-consuming to devise; there is no assurance that full-scale international negotia-

tions on the provisions of specific arrangements will be successful. It follows that building in flexibility at the outset makes sense, whether this is achieved by articulating general principles while granting considerable discretion to those responsible for implementation in each state, as in the case of the polar bear regime, or by creating a commission or a board capable (at least in principle) of making adjustments to cope with changing conditions, as in the cases of the regime for the Porcupine caribou herd or the now defunct regime for the northern fur seal.

- Where managers and users constitute distinct groups, a necessary condition for success is the creation of some mechanism to give users a say in the management process. This seems especially important in areas, like the Arctic, where the users are often indigenous peoples and the managers are typically representatives of the dominant culture. At the same time it is important to avoid predictable pitfalls in meeting this condition. The absence of an American counterpart to the Canadian Porcupine Caribou Management Board, for example, is a source of trouble for the bilateral caribou regime. By contrast the 1988 Inuvialuit Game Council/North Slope Borough Fish and Game Management Committee Agreement on Polar Bear Management in the Southern Beaufort Sea, which spells out detailed regulations covering the taking of polar bears along the Beaufort Sea coast, appears to be a useful supplement to the basic five-nation polar bear regime.

## *Principles for Managing the Arctic's Resources*

Guiding philosophies, perspectives and principles exercise a generative influence on the institutional arrangements that humans devise. The force of this proposition is just as strong with regard to regimes designed to manage the shared resources of the Arctic as it is in any other walk of life. To conclude these impressions, therefore, we have sought to distill some basic principles from the argument set forth in the preceding sections. In doing so, we make no effort to mask our preference for arrangements that reflect what we have called an ecological perspective, which grants priority to the pursuit of harmonious human-environment relationships over contentious jurisdictional debates and which give full play to the northern voice in decisions regarding the management of shared



Arctic resources. We do not regard this as a form of antisouthern bias, since southerners are coming to see the value of integrating northerners and northern views into decision-making on Arctic issues. The long-term interests of all users, in our view, should benefit from the development of resource regimes based on such principles.

### *The Principle of Sustainability*

The Arctic's resources and the ecosystems of which they are a part must be used in a manner that allows for harmonious human-environment relations over time. This is, in part, a matter of intertemporal or intergenerational justice. Even more fundamentally, however, practices that conform to this principle are part of a way of life in which humans are seen as constituents of natural systems rather than as masters ruling over them and in which stewardship rather than dominion is the criterion of evaluation against which human actions are to be measured.

### *The Principle of Devolution*

The fundamental aim in managing shared Arctic resources is the achievement of sustainable and equitable relationships among multiple resource users by the users themselves. Management regimes for shared Arctic resources must provide opportunities for effective participation on the part of all those with legitimate interests in the resources in question. This does not mean that every in-

terest group should have a say in all decisions relating to the management of the Arctic's resources. But it does mean that those whose circumstances, livelihood and culture are likely to be directly affected by decisions relating to the management of specific resources, such as subsistence users in the Arctic, must have a voice that counts, whether the relevant forum is a local game board or an international negotiation of the type leading to the adoption of the Arctic Environmental Pollution Strategy in 1991.

### *The Principle of Reassessment*

Arctic resource regimes should encompass mechanisms that make it possible to conduct periodic assessments of their performance as a matter of course. The animal populations of the Arctic and the ecosystems of which they are a part are subject to large and rapid fluctuations. Similar fluctuations occur in rates of exploitation of nonrenewable resources in the circumpolar North. As well, the Arctic is a region experiencing change on many other fronts. These changes involve human settlement patterns and relations between human communities and the biological and physical systems in which they are situated. It follows that practices involving the human use of natural resources that work well today may not be appropriate in the future. To cope with this situation in an orderly fashion, it is important to build review procedures into management regimes at the outset so that efforts to engage in normal reassessment do not become stymied by conflicts of interest among the stakeholders.

# Arctic Environmental Protection Strategy

*The U.S. delegation was headed by Ambassador John Giffen Weinmann and included: Ray Arnando, Head, U.S. Working Group; Jerry Brown, National Science Foundation; William Chubb, U.S. Coast Guard; David Cline, National Audubon Society; Ed Myers, NOAA; Courtney Riordon and Robert Worrest, EPA; Max Robison and Ralph Goff, American Embassy, Helsinki.*

In September 1989, on the initiative of the government of Finland, officials from the eight Arctic countries met in Rovaniemi, Finland, to discuss cooperative measures to protect the Arctic environment. They agreed to work towards a meeting of circumpolar ministers responsible for Arctic environmental issues. The September 1989 meeting was followed by preparatory meetings in Yellowknife, Canada, in April 1990; Kiruna, Sweden, in January 1991; and Rovaniemi, Finland, in June 1991 (see *Arctic Research of the United States*, Fall 1990, p. 70 for background).

The Declaration on the Protection of the Arctic Environment was signed on June 14, 1991, at a ministerial-level meeting in Rovaniemi, Finland, by ministers of the eight Arctic countries. The agreement consists of objectives and principles, as well as summaries of reports on the state of the Arctic environment (chlorinated organics, heavy metals, oil, radioactivity, acidification and noise) and international mechanisms for the protection of the Arctic environment. Actions to be undertaken include an Arctic Monitoring Assessment Program (AMAP), cooperation for Emergency Prevention,

Preparedness and Response, and an Exchange of Information on Arctic Flora and Fauna.

The latest working group meeting was held on 10–13 June 1991, just prior to the ministerial meeting. In addition to the delegations from the eight Arctic countries, there were observers from Germany, Poland, the United Kingdom, the International Arctic Science Committee (IASC), the Inuit Circumpolar Conference (ICC), the Nordic Saami Council, the U.S.S.R. Association of Small Peoples of the North, and the UN Economic Commission for Europe (ECE) and UNEP.

The next meeting is planned for 1993 in Greenland. The AMAP plans to meet in Tromsø in early December 1991. Canada plans to convene a meeting on flora and fauna in 1992, and Sweden plans to host an expert meeting in 1992 on emergency prevention, preparedness and response in the Arctic. The State of Environment reports were published in a special volume and are available as University of Lapland, Arctic Center Report No. 2.

The full text of the Declaration and excerpts from the Strategy, including the introduction, objectives, principles and actions, follow.

## *Declaration on the Protection of the Arctic Environment*

We, the Representatives of the Governments of Canada, Denmark, Finland, Iceland, Norway, Sweden, the Union of Soviet Socialist Republics and the United States of America;

Meeting at Rovaniemi, Finland for the First Ministerial Conference on the Protection of the Arctic Environment;

Deeply concerned with threats to the Arctic environment and the impact of pollution on fragile Arctic ecosystems;

Acknowledging the growing national and international appreciation of the importance of Arctic ecosystems and an increasing knowledge of global pollution and resulting environmental threats;

Resolving to pursue together in other international environmental fora those issues affecting the Arctic environment which require broad international cooperation;

Emphasizing our responsibility to protect and preserve the Arctic environment and recognizing the special relationship of the indigenous peoples and local populations to the Arctic and their unique contribution to the protection of the Arctic environment;

Hereby adopt the Arctic Environmental Protection Strategy and commit ourselves to take steps towards its implementation and consider its further elaboration.

We commit ourselves to a joint Action Plan of the Arctic Environmental Protection Strategy which includes:

- Cooperation in scientific research to specify sources, pathways, sinks and effects of pollution, in particular, oil, acidification, persistent organic contaminants, radioactivity, noise and heavy metals as well as sharing of these data;
- Assessment of potential environmental impacts of development activities;
- Full implementation and consideration of further measures to control pollutants and reduce their adverse effects to the Arctic environment.

We intend to assess on a continuing basis the threats to the Arctic environment through the preparation and updating of reports on the state of the Arctic environment, in order to propose further cooperative action.

We also commit ourselves to implement the

## *Actions*

The eight Arctic countries agree to proceed cooperatively with the following action plan. These commitments will begin the process of addressing the serious environmental issues identified and assessed through the preparation of specific state of environment reports. These issues will require regular updates for evaluation by the eight Arctic countries on the progress being made, and to advise on possible new courses of action.

### *Persistent Organic Contaminants*

- i) In order to further define the likely sources, pathways, sinks and effects of these pollutants, and to expand the data base to cover all the component parts of the Arctic environment, the eight Arctic countries will undertake cooperative monitoring (AMAP) and research related to the problem of persistent organic contaminants in the Arctic ecosystem.
- ii) The Arctic countries will consider the feasibility of developing national inventories on the production, use, and emissions of persistent organic contaminants (e.g. pesticides) to be collected, and made available and summarized in the state of the Arctic environment reports.
- iii) The Arctic countries will also address the problem of persistent organic contaminants under existing or proposed international agreements and will review other mechanisms to advance this issue in other international fora.
- iv) In order to achieve an early reduction in the movement of persistent organic contaminants into the Arctic environment, the eight Arctic countries will support the process now under way within the UN ECE LRTAP Convention to further define the problem and to develop proposals for international action on the control of these substances under the Convention. Those Arctic countries which are partners to the Paris and Helsinki Conventions will actively support ongoing inventory and assessment work under those conventions.
- v) The Arctic countries agree to implement measures to reduce and/or control the use of the following polluting substances: chlor-dane, DDT, toxaphene and PCBs. Those Arctic countries which have not already done so, also recognize that the elimination of the problem of persistent organic contaminants in the Arctic may also require controls on the production of these substances.

- vi) The Arctic countries will review the situation with regard to other persistent organic contaminants with a view to establishing priorities and timetables for a program of emission elimination or control in cooperation with other international fora.

### *Oil Pollution*

- i) In order to achieve better documentation of the level of oil pollution in the Arctic environment, the initiation of monitoring of hydrocarbons as a part of the AMAP will play an important role.
- ii) There is also a need to consider establishment of a reporting system on discharges and spills, with regard to providing adequate documentation on the pollution threat, in the Arctic.
- iii) The elements agreed upon in Section 7, Protection of the Arctic Marine Environment and Section 8, Emergency Prevention, Preparedness and Response will comprise the basis for further cooperation in preventing and combatting oil pollution.
- iv) The Arctic countries agree to take measures as soon as possible to adhere to the strictest relevant international standards within the conventions, to which the countries are parties, regarding discharges irrespective of origin.
- v) The Arctic countries agree to undertake joint actions in relevant international fora to further strengthen recognition of the particularly sensitive character of ice-covered parts of the Arctic Ocean.

### *Heavy Metals*

- i) An improved understanding of the dynamics of heavy metals in the Arctic ecosystem is required. The countries will undertake a program of coordinated monitoring (AMAP) and research to identify sources, pathways and sinks of heavy metals; spatial and temporal trends; and ecological effects with special emphasis on human health effects.
- ii) The eight Arctic countries agree to implement measures to control conditions that lead to the release of heavy metals by industrial activities including as appropriate the implementation of best available technology and other concerted actions in accordance with appropriate international agreements (e.g. UN ECE LRTAP Convention).

## Noise

- i) The effects of noise associated with Arctic marine and terrestrial projects should be evaluated as part of the project planning and approval processes, and if significant adverse noise effects on the specific components of Arctic ecosystems are predicted, then measures should be implemented to avoid or mitigate the impact.
- ii) Efforts should be made to improve the knowledge on marine mammal auditory function, communication and behavior and the current noise exposure assessment techniques. For specific project evaluations, site-specific data should be addressed before and during the evaluation. This includes determining how much exposure migrating stocks are encountering throughout the year.

## Radioactivity

- i) AMAP should address radioactivity. Common standards and techniques for monitoring and analysis, consistent with IAEA standards and technology should be developed.
- ii) Future monitoring and health assessments should consider the effects from exposure to radiation from man-made sources together with natural or background radiation.
- iii) Further consideration should be given to the development of more specific measures, consistent within the international legal framework of IAEA procedures, for co-operation amongst Arctic countries to deal with emergencies caused by the accidental release of radioactive substances and to provide mutual assistance in the harsh Arctic environment.
- iv) All relevant data concerning previous studies and measurements should be collated in the existing relevant data bases of which information should be exchanged between the governments and institutions concerned.

## Acidification

- i) Regional Arctic research programs should be developed to assess the current loadings and potential effects of acid deposition on representative sensitive Arctic ecosystems. Special attention should be given to those regions or ecosystems for which existing data or assessments suggest that there is or is likely to be an acidification problem.
- ii) Consideration should be given to expanding deposition monitoring programs, within

the framework of AMAP and existing networks such as the ECE/EMEP deposition monitoring network, to encompass measurement of acid deposition in the Arctic. Emphasis should also be placed on measuring dry deposition.

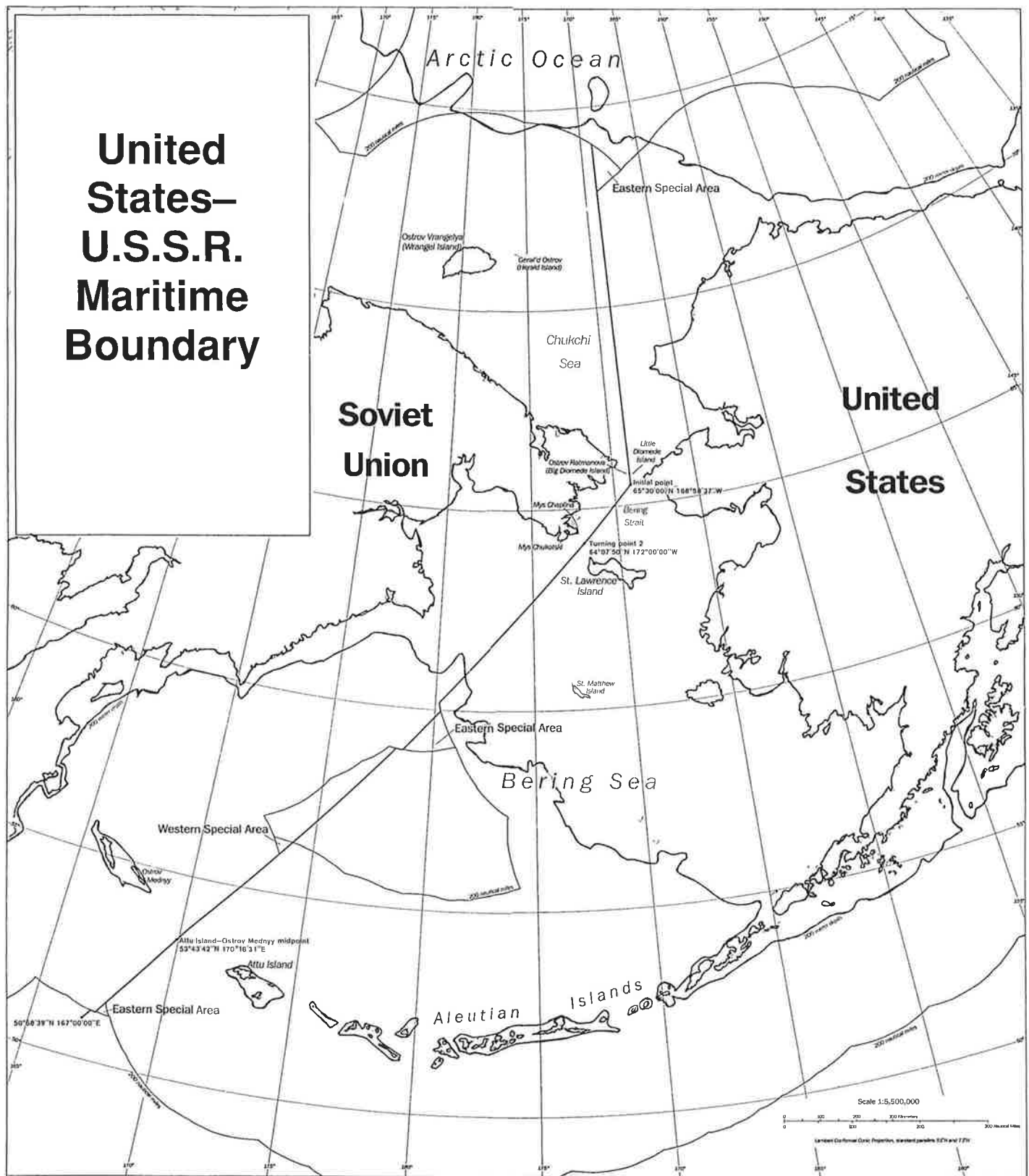
- iii) Emphasis should be placed on defining critical loads and setting target loads for sensitive Arctic ecosystems. In the event that these target loads are being exceeded, steps should be taken to reduce those emissions contributing to the problem, in accordance with international agreements such as the ECE LRTAP Convention. Reduction of emissions of sulphur and nitrogen should be sought by, *inter alia*, implementing the use of the best available technology.

## Arctic Monitoring and Assessment Program

- i) Distinguishing human-induced changes from changes caused by natural phenomena in the Arctic will require estimates and regular reporting by the Arctic countries of contaminant emissions and discharges, including accidental discharges, as well as transport and deposition. In addition monitoring of deposition and selected key indicators of the Arctic biological environment are required. The eight Arctic countries should therefore establish an Arctic Monitoring and Assessment Program (AMAP) to fulfill these monitoring objectives.
- ii) The AMAP should be implemented through the establishment of an Arctic Monitoring and Assessment Task Force and a small secretariat, established by the Government of Norway.
- iii) AMAP should as far as possible build upon existing programs. Thus, one of the important tasks of the AMAP will be to review and coordinate existing national programs, establish a data directory, and to develop these programs when appropriate in an international framework.
- iv) As an initial priority, the AMAP should focus on persistent organic contaminants and on selected heavy metals and radionuclides, and ultimately to monitor ecological indicators to provide a basis for assessments of the status of Arctic ecosystems.
- v) The eight Arctic countries will receive regular *State of the Arctic Environment Records* summarizing the results of the AMAP.

As a result of these actions, the Arctic Monitoring and Assessment Program will provide information for:

# United States— U.S.S.R. Maritime Boundary





# Recent U.S.–U.S.S.R. Agreements Relating to the Bering Region

DAVID SHAKESPEARE

Soviet–American relations in Beringia go back over 200 years to a time when explorers and fur seal traders dominated the region. The abundant marine and coastal resources of the region, such as gold, fur from the northern fur seal, and ivory from walrus, provided incentives for an extensive trading system. The history of European, Soviet and American prominence in Beringia is also noted for its exploitation of the indigenous people living on the Russian and American mainlands as well as on the islands of the Bering Sea.

Travel and trade among all inhabitants and visitors to Beringia were common from the mid-1700s until shortly after World War II. With the beginning of the Cold War in 1948, an “ice curtain” ended this remarkable historical period, making all trade and visits impossible both for Natives and non-Natives alike. Military observation and electronic listening posts were established on each side of the border.

The ice curtain remained in place for nearly forty years. Despite the restrictions on trade and travel during this period, the governments of the United States and the Soviet Union continued, however, to negotiate agreements on fisheries, conservation and scientific cooperation in Beringia. Looking at the history of Beringian natural resource agreements signed by the superpowers since 1948, we can identify two periods of intense activity: the early 1970s and most recently from around 1988 to the present. The principal difference between the two periods is that the agreements signed in the early 70s concentrated primarily on fisheries and conservation issues, while the new agreements focus on wide-ranging approaches from the national, state and regional levels of government as well as the private sector.

On the national level recent Soviet–American agreements range from visa-free travel arrangements for indigenous people to a joint statement declaring the intent of the two nations to establish a Beringian Heritage International Park. On the state and regional level, Alaska and the Magadan Oblast have recently signed several agreements, including one that encourages scientific cooperation in circumpolar health issues. In the private sector are a series of agreements, including several between U.S. and Soviet environmental organizations.

This paper examines the recent proliferation of

bilateral agreements relating to Beringia on the national, state and regional levels, as well as the private sector. While this is not an exhaustive list of the recent agreements relating to Beringia, it gives an indication of the number and breadth of such agreements in the past four years. [For an excellent summary of recent Alaskan–Soviet scientific cooperation in Beringia, see Fischer (1990). For information on the history of U.S.–U.S.S.R. scientific cooperation in Beringia, see Loughlin (1985).] This paper concludes with a look at future problems and prospects for Soviet–American cooperative activities in Beringia. Special attention is given to the growing problem of multiple-use conflicts over natural resources and the emerging consensus on the need for a new management regime for the region.

## Agreements in the 1970s

Despite the tendency of the Cold War to dampen almost all American–Soviet interactions in Beringia (except military), there continued to be occasional flurries of diplomatic activity between the two nations. Most of these negotiations involved bilateral and multilateral agreements dealing with the rich fisheries of the region. Some of the more important of the multilateral agreements include the Agreement on Conservation of Polar Bears, the North Pacific Fur Seal Convention and the International Whaling Convention. Various bilateral agreements concerning gear restrictions and distribution of fishing rights were also signed during this period.

The early 1970s was a productive period for agreements that either directly or indirectly affected Beringia. Many of these agreements were extensions or amendments to previously negotiated agreements on fishing rights in the North Pacific or allowable catches of tanner and king crabs off the continental shelf. Two new bilateral agreements of significance were signed in 1972 and 1973: the U.S./U.S.S.R. Agreement on Cooperation in the Field of Environmental Protection, and the Agreement Relating to the Consideration of Claims Resulting from Damage to Fishing Vessels or Gear and Measures to Prevent Fishing Conflicts.

The 1972 U.S./U.S.S.R. Agreement on Cooperation in the Field of Environmental Protection in-

*For the purposes of this paper, Beringia is defined as the Bering and Chukchi seas, together with their coastal littorals and islands.*

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cludes plans for cooperative work in eleven major areas. Areas of particular significance to Beringia include Area 4, Enhancement of the Urban Environment; Area 5, Protection of Nature and the Organization of Reserves; Area 6, Protection of the Marine Environment from Pollution; Area 10, Arctic and Subarctic Ecological Systems; and Area 11, Legal and Administrative Measures for the Protection of Environmental Quality. Specific accomplishments evolving from the 1972 agreement range from the 1976 U.S./U.S.S.R. Migratory Bird Convention to the 1988 Agreement Concerning Cooperation in Combatting Pollution in the Bering and Chukchi Seas in Emergency Situations, and the recently announced intent of the two governments to establish the Beringian Heritage International Park.

The 1973 agreement relating to the Consider-

ation of Claims Resulting from Damage to Fishing Vessels or Gear and Measures to Prevent Fishing Conflicts sets up a claims settlement procedure for U.S.-U.S.S.R. gear conflict resolution. "The U.S.-U.S.S.R. Fisheries Claims Board facilitated the settlement of claims put forth by nationals of one country against nationals of another but, more importantly, it established a set of rules that each party recommended to their nationals to reduce the number of conflicts" (Miles et al. 1982).

The next and last major development to affect Beringia between the late 1970s and 1988 was the extension of fishery conservation zones to 200 miles, known also as exclusive economic zones under the 1982 Law of the Sea Convention. In 1976 both the United States and the Soviet Union extended their fishery conservation zones to 200 miles from the baseline of their coasts. The purpose of these jurisdictional changes was to prohibit distant water fishing fleets from overexploiting the resources of the coastal state, thereby allowing the coastal state to receive the financial benefits of harvesting these resources itself and to impose more effective conservation measures.

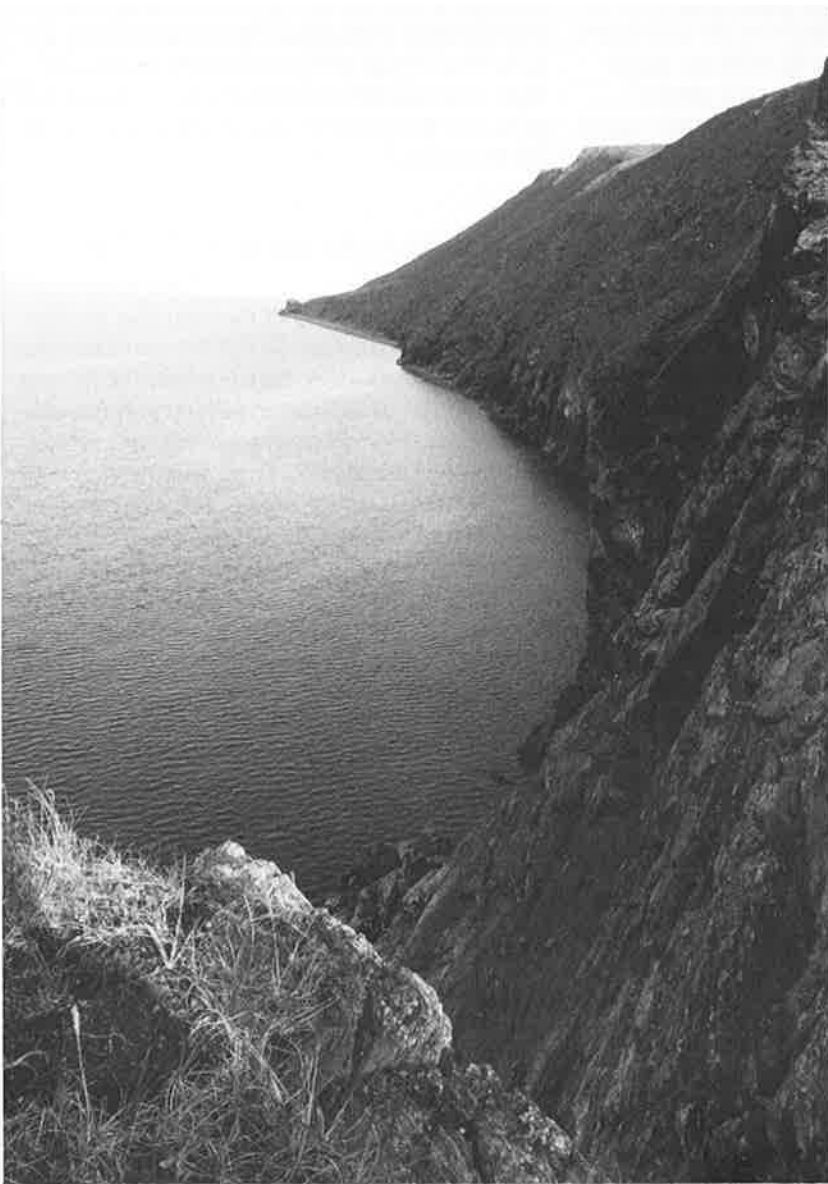
While in many cases these goals were met, the exclusive economic zones created new problems for the Soviet and American fisheries in Beringia. These problems include the "donut hole" issue and the U.S.-U.S.S.R. boundary line dispute in the Bering Sea. The latter issue has been solved in the Maritime Boundary Agreement signed in June 1990. The donut hole issue, which will be discussed in greater detail in the conclusion, is still a problem. Both issues involve poorly defined jurisdictional arrangements in the Bering Sea, leading to conflicts over fishing rights and the exploitation of resources.

## Agreements in the 1980s

Relations between the Soviet Union and the United States reached an all-time low between the late 1970s and the mid-1980s. Political and military tensions between the two nations affected Beringia in several ways. In 1983 the Korean Airlines flight 007 was shot down by a Soviet MiG fighter plane after crossing Soviet airspace above sensitive military installations in Kamchatka. A ban on travel and trade in Beringia continued, and on several occasions Americans who strayed across the border in the Bering Strait were arrested and later released by Soviet border guards.

In the late 1980s, following the political and economic changes within the Soviet Union, relations between the two countries began to improve

*Seabird nesting cliff near the village of Inchoun on the Soviet side of the Chukchi Sea.*



significantly. The first of these improved relations in Beringia occurred on the cultural level. In August 1987, American marathon swimmer Lynne Cox received Soviet permission to swim from Little Diomed (U.S.) to Big Diomed (U.S.S.R.) Island. On June 13, 1988, a group of Alaska officials, Natives and representatives of the national press flew from Nome to Provideniya on a so-called Friendship Flight. The flight was welcomed by hundreds of Provideniya schoolchildren and adults, as well as officials from Provideniya and Chukotka. Gathering momentum, Soviet-American relations in Beringia progressed from cultural and symbolic exchanges to serious negotiations on political and economic issues in the region.

### *National Agreements*

#### *United States-Soviet Union Fishery Agreement (Governing International Fishery Agreement of 1988)*

Governing International Fishery Agreements (GIFAs) are required under the U.S. Fishery Conservation and Management Act of 1976, the act that extended U.S. fishery jurisdiction out to 200 miles. The GIFA allows a foreign nation that is party to the agreement to receive an allocation of part of the "total allowable level of foreign fishing" (TALFF). The 1988 U.S.-U.S.S.R. Fishery Agreement was adopted as the new GIFA between the two nations. Its significance lies in the fact that not only will the two countries cooperate in fishery scientific research and trade, but also for the first time U.S. fishermen will be allowed to work in Soviet waters and Soviet fishermen will be given access to U.S. waters. The agreement also calls for cooperation in managing and conserving anadromous fish (mainly salmon) in the North Pacific and groundfish (mainly pollock) in the Bering Sea and in establishing an International Coordinating Committee (ICC) as the organizational structure for implementing the agreement. Thus established, the ICC created a separate working group called the Bering Sea Fisheries Advisory Body. This group is charged with identifying and assessing the pollock resources of the Bering Sea, establishing a common data bank and determining appropriate overall harvest levels.

#### *Agreement Between the United States of America and the Union of Soviet Socialist Republics on Maritime Search and Rescue, May 1988*

The implementing agencies of this agreement are the U.S. Coast Guard and the Soviet Ministry

of Merchant Marine. Under this agreement both countries have established two primary search-and-rescue coordination centers: Juneau for the United States and Vladivostok for the Soviet Union. These centers test their communications equipment (telephones and telex and facsimile machines) every six months to verify operability and procedures.

The U.S. position on entry into Soviet territory in the case of an emergency is that permission must be granted for a search but not for a rescue. The latter is contingent upon the condition that the rescue is an emergency, that the location is reasonably well known, and that there are no Soviet rescue teams closer to the victim(s). This position is consistent with customary international law, the Law of the Sea Convention, and the International Convention on Maritime Search and Rescue (under the International Maritime Organization). Since the U.S./U.S.S.R. Maritime Search and Rescue Agreement was signed in 1988, there has been an average of three to four rescues per year in the Bering Strait region involving both U.S. and Soviet forces. There is concern that the search and rescue points of contact on the Soviet and American coasts are too far away (Vladivostok and Juneau) to be effective for the Bering Strait; there have been no joint Soviet-American search and rescue exercises; and emergency medical evacuation procedures and equipment are not yet readily available on either side of the Strait.

#### *Agreement Concerning Cooperation in Combatting Pollution in the Bering and Chukchi Seas in Emergency Situations, May 1989*

This agreement was facilitated by Area 6 of the U.S.-U.S.S.R. Agreement on Cooperation in the Field of Environmental Protection. Its stated purpose is to "render assistance to each other in combatting pollution incidents which may affect the areas of responsibility of the Parties, regardless of where such incidents occur. To such end the competent authorities of the Parties shall develop the Joint Contingency Plan Against Pollution in the Bering and Chukchi Seas."

According to Lt. McEwan of the United States Coast Guard, there have been several boardroom (situational) exercises of the Joint Contingency Plan in the United States. The Soviets have participated in these exercises as observers. In the future it is hoped that both countries will participate in field as well as boardroom exercises. One recent practical benefit of the agreement was the Soviet participation in the cleanup of the *Exxon Valdez*

oil spill in Prince William Sound, Alaska. The Soviets provided oil skimmers.

*Agreement on the Prevention of Dangerous Military Activities, June 1989*

This is the only one of the recent agreements between the United States and the Soviet Union that addresses military problems in Beringia. It builds upon two previous agreements—the Agreement on the Prevention of Incidents on and over the High Seas, May 25, 1972, and the trilateral Memorandum of Understanding among the United States of America, Japan, and the Union of Soviet Socialist Republics Concerning Air Traffic Control, July 29, 1985. The trilateral Memorandum of Understanding was a result of the downing of the Korean Airlines jet in 1983. The memorandum established coordination of activities among the Anchorage, Tokyo and Khabarovsk air traffic control centers to assist civilian aircraft in emergency situations.

The scope of the agreement is described in the *Harvard International Law Journal*: “The basic themes underlying the Agreement [on Dangerous Military Activities] are the two states’ intent both to prevent dangerous military activities and to resolve any incidents that arise as a result of such activities. These two themes echo throughout the four major areas covered by the Agreement: border crossings; use of lasers; ship and troop maneuvers in regions of high tension; and interference with command and control networks” (Feher 1990). Since the Bering Strait is the shortest distance between the Soviet and American borders with significant military presence on both sides of the border, this agreement definitely applies to Beringia.

The agreement calls for the establishment of a Joint Military Commission, “which will meet annually to consider compliance with the Agreement’s obligations, possible ways to increase the safety level of equipment and personnel, and other measures necessary to strengthen the effectiveness of the Agreement.”

The Agreement has led, so far, to one joint exercise on December 7 and 8, 1989, in which the pilots of two American F-15s and two Soviet Bear bombers, meeting over the Bering Sea, spoke with each other using a prepared script.

*Agreement Concerning Mutual Visits by Inhabitants of the Bering Straits Region, September 1989*  
*(Visa-free Travel Agreement)*

This agreement allows U.S. and Soviet native inhabitants of the Bering Strait region to visit relatives in the other country using a passport and an

insert to the passport stating that they are inhabitants of the designated American or Soviet area. Under the terms of the agreement, relatives include “blood relatives, fellow clan or tribe members, or native inhabitants who share a linguistic or cultural heritage with native inhabitants of the other territory.” The Native inhabitants are allowed to visit relatives in “designated areas” only if they have received an invitation from the relatives. The designated American area includes the Nome and Kobuk census areas of Alaska. The designated Soviet area includes the Iultinskiy Rayon, Providenskiy Rayon and Chukotsky Rayon, as well as the eastern part of the Anadyrskiy Rayon. Inhabitants may not enter or leave United States or Soviet designated areas without first notifying a Chief Commissioner of the respective country. Each country must establish a Chief Commissioner as part of the Agreement Concerning the Bering Straits Regional Commission (see below).

As of June 1991 the exchange of notes necessary for the Agreement to go into effect has not occurred. Until then the United States Immigration and Naturalization Service has been allowing Soviet native inhabitants to enter the United States under the INS parole system.

*Agreement Concerning the Bering Straits Regional Commission, September 1989*

The governments of the United States and the Soviet Union “have agreed to create the Bering Straits Regional Commission for the settlement of local minor incidents.” The commission will include three American members and three Soviet members. Each country will designate one of its members as the Chief Commissioner. “The official seat and district of operation of the Chief Commissioners shall be as follows: on the part of the U.S., the Commissioners shall have permanent seats in Gambell and Nome. The district of operation shall be the Nome and Kobuk census areas of Alaska. On the part of the U.S.S.R., the Commissioners shall have permanent seats in Provideniya and Anadyr. The district of operation shall be the Iultinskiy Rayon, Providenskiy Rayon, and Chukotsky Rayon, as well as the eastern part of the Anadyrskiy Rayon.”

As of June 1991 all six commission members have been appointed: three from the United States and three from the Soviet Union. Each country has also nominated one of its commission’s members as Chief Commissioner for its side of the Bering Strait. Exchange of notes to formally establish the Bering Straits Regional Commission was expected this summer.

*Joint Statement of Intent to Establish  
Beringian Heritage International Park,  
January 1990*

The proposal for the Beringian Heritage International Park is a result of negotiations under Area IV of the 1972 U.S.-U.S.S.R. Agreement on Cooperation in the Field of Environmental Protection. The purpose of the International Park is to advance bilateral cooperation in conserving and protecting the natural and cultural heritage of the Beringian region. The park will be implemented by the U.S. National Park Service and the State Committee for Environmental Protection of the Russian Republic.

Since the signing of the Joint Statement to Establish the Beringian Heritage International Park (June 1, 1990), there has been much progress. Several U.S.-Soviet meetings to discuss joint research and scientific investigations related to the park have been held. Meetings between government, regional, local and indigenous representatives have also been held on both sides of the Bering Strait to discuss the park proposal. A joint U.S.-U.S.S.R. park seminar was held in Provideniya in August 1991. Plans for the near future include completion of the park development and feasibility study. United States legislation to designate the Bering Land Bridge National Preserve formally as the U.S. portion of the international park has been drafted; introduction and passage of the legislation is expected in late 1991 or 1992. The Soviet portion of the international park has not been designated yet but will probably include terrestrial and marine areas of the Chukotsky Peninsula. The Soviets are expected to finish preplanning field work for their side of the park and to have an internal management plan ready for presentation to the Russian Republic and Council of Ministers by 1992 (U.S. National Park Service, RSFSR Goskompriroda, in press).

Despite the apparent progress the international park will probably be officially established after the December 1991 deadline originally announced. The initial deadline now seems unrealistically short, given the legal, administrative and political difficulties entailed in creating the first international park to be co-managed by the two superpowers.

Solving the difficulties on the Soviet side has been particularly time-consuming because of the objectives and scope of their portion of the park, the lack of Soviet experience with creating parks, and the Union-Republic relationships. The objectives include protection of the natural and cultural heritage of Beringia (also included in the park objectives of the United States), as well as develop-

ment of new legal structures to protect the traditional subsistence lifestyles of the Native people of Chukotka. The Native subsistence issues as they relate to the Beringian Park have already been addressed in the United States under the Alaska National Interest Lands Conservation Act (ANILCA) of 1980. Another legal issue that must be addressed by the Soviets is how to include marine as well as terrestrial areas on their side of the park. The United States has avoided this problem so far by relegating its portion of the park to terrestrial areas only. The relative lack of Soviet legal and administrative experience with establishing parks and preserves on the national and international level has also slowed progress on the Beringian Heritage International Park. Finally the ongoing friction between the Union government and the Republics has hindered the cooperation and continuity necessary for rapid implementation of the park.

Solving the legal and administrative problems with the park in the United States has been simplified because a pre-existing preserve (the Bering Land Bridge National Preserve) has been designated as the U.S. portion of the international park, marine areas are not currently being considered for the U.S. portion, and Native subsistence rights have been addressed under ANILCA.

*Civil Air Transport Agreement Between  
the United States of America and the  
Union of Soviet Socialist Republics,  
May 1990*

The Civil Air Transport Agreement is an amendment to the 1966 Civil Air Transport Services Agreement, which allowed service by only two airlines—Pan Am and Aeroflot—between Moscow, Leningrad, Washington and New York. The expanded agreement would allow total passenger and cargo flights per side to increase from 7.6 Boeing-727 equivalents per week to 15.1 immediately; to 42 on April 1, 1991; and to 58 on April 1, 1992. Under the agreement the United States airlines can increase services to Moscow and Leningrad, and they will gain new rights over the North Atlantic, allowing them access to four additional cities, and over the Pacific to two additional cities. Also under the agreement, Soviet airlines can increase services to New York and Washington, and they will gain new rights over the Atlantic to two additional cities (with onward service to South America) and over the Pacific to two additional cities.

The Civil Air Transport Agreement will allow Alaska Airlines flights to the Soviet Union over



# *New Marine Science Organization in the North Pacific*

WARREN WOOSTER

In the last several decades, a variety of international organizations have been established, or have assumed responsibility, for one or another aspect of marine science and its applications. There are important global bodies within the United Nations family—for example, the Intergovernmental Oceanographic Commission (IOC) of Unesco, the Food and Agriculture Organization (FAO) and the World Meteorological Organization (WMO). Others are in the nongovernmental International Council of Scientific Unions—for example, the Scientific Committee on Oceanic Research (SCOR).

While global organizations have important capabilities and responsibilities, detailed consideration of many questions is better done at the regional level. For this reason the UN organizations also commonly include regional subbodies. There are also a variety of regional fishery commissions; some are under FAO while others are independent.

The oldest international marine science organization, founded in 1902, is the International Council for the Exploration of the Sea (ICES). It is devoted to promotion of "research and investigations for the study of the sea particularly related to the living resources thereof" and has 17 member countries including all maritime states in northern Europe plus Canada and the United States. Geographically its interests lie in the eastern North Atlantic, including the North, Norwegian and Baltic seas and extending into the Greenland and Barents seas.

ICES holds annual scientific meetings and other symposia and has organized many cooperative investigations in its region of interest. While it is a scientific organization with no management responsibility or authority, it has an important role in assessing available scientific information and interpreting it not only for its members but also for organizations with management responsibilities. This advisory role pertains to fishery management and pollution control. The ICES reputation for objectivity in its scientific analyses derives from its independence from the management bodies, which on their part must balance scientific evidence with economic, social and political realities.

## *Development of a Pacific ICES*

There are few ICES analogs in the world. The lack is particularly conspicuous in the northern North Pacific, where there are not only interesting scientific questions related to atmosphere and ocean circulation and their effects on marine ecosystems,

but also important ocean uses, particularly of fish stocks in the subarctic Pacific and the Bering Sea. Also, it is increasingly apparent that these questions are all connected: the circulation of the atmosphere and ocean and their interactions are related to climate change questions, to the transport and diffusion of pollutants and to the variable distribution of organisms and production in marine ecosystems.

From this viewpoint the traditional allocation of problems to discipline-oriented agencies and departments is no longer adequate. For example, if variable fish production is a consequence not just of fishing pressure but of environmental change, its understanding requires data, ideas and investigations not just from fishery laboratories but also from those concerned with atmospheric science and climatology and with physical, chemical and biological oceanography.

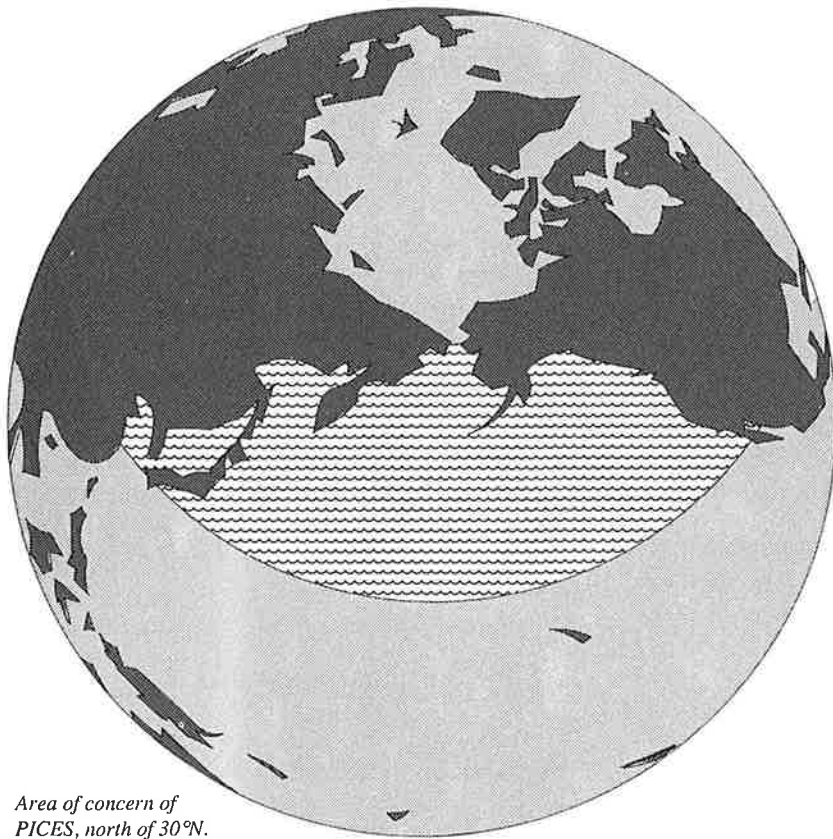
The idea of a north Pacific ICES, or PICES, was first proposed during an FAO conference in Vancouver in 1973 but was not discussed in a systematic way until the late 1970s. Several informal meetings were then held in Seattle where scientists from Canada, Japan, the Soviet Union and the United States exchanged views. Although many of the concepts that characterize PICES were developed in these discussions, the time was not propitious for bringing the idea to fruition. Impediments included the ongoing Law of the Sea negotiations and the difficult political relations between the U.S. and the U.S.S.R. in the early 1980s.

It was only in 1986 during an informal meeting in Anchorage, which included Chinese participants for the first time, that agreement was reached to seek an intergovernmental discussion of a possible new regional marine science organization. Participants agreed to urge the Canadian government to convene such a conference, which was held in Ottawa in December 1987. A second conference in Sidney, British Columbia, in December 1988 and a drafting meeting in Seattle in December 1989 were necessary before agreement was finally reached in Ottawa on 12 December 1990 to establish the North Pacific Marine Science Organization (PICES). Representatives of Canada, China, Japan, the United States and the Soviet Union initialled the draft convention.

## *Purpose and Function of PICES*

The organization has the following principal purpose:

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Area of concern of  
PICES, north of 30°N.

to promote and coordinate marine scientific research in order to advance scientific knowledge of the area concerned and of its living resources, including but not necessarily limited to research with respect to the ocean environment and its interactions with land and atmosphere, its role in and response to global weather and climate change, its flora, fauna and ecosystems, its uses and resources, and impacts upon it from human activities (Article III.a).

To achieve this purpose, PICES will identify research priorities and problems, recommend coordinated research programs, promote the exchange of scientific data, information and personnel, develop scientific advice upon request, and organize scientific discussions and symposia.

The area of concern is the temperate and sub-arctic region of the North Pacific Ocean and its adjacent seas, especially north of 30°N. The Bering Sea will be an important focus of attention.

PICES will have no management responsibilities or authority. However, it is anticipated that the organization will develop a role, analogous to that of ICES, in the objective assessment of scientific data and information, which can be made available to its member states and to organizations concerned with management. Such assessments might concern issues such as the eventual consequences of climate change for the use of the ocean and its

resources, the impacts of oil spills, debris and other forms of ocean pollution, and the effects of human activities and environmental change on fish stocks.

## Status

The Convention will come into force after ratification by three of the five signatory states. This might occur early in 1992, after which the Government of Canada will convene a meeting of the PICES Governing Council. It is anticipated that other countries with scientific interests in the region will wish to accede to the Convention. Cooperative links will be developed with other international organizations with common interests.

A small PICES secretariat will be located at the Institute of Ocean Sciences in Sidney, British Columbia. Warren S. Wooster of the University of Washington is serving as PICES Chairman pro-tem. If PICES develops along the lines of ICES, it will work mostly through scientific committees of specialists, who will meet in joint sessions when interdisciplinary questions are being considered. Initially there might be four such committees, perhaps in physical oceanography and climate, biological oceanography, fishery science and environmental quality. If there are no unexpected delays, the organization should become fully functional by the end of 1992.

Meanwhile, the First PICES Scientific Workshop will be held in Seattle before the end of 1991. This is intended to review the state of knowledge on the topics listed below, to identify research gaps and priorities, and to consider joint action that might be developed through PICES. Topics selected for this initial examination are:

- The Bering Sea: Should a sea-wide comprehensive study involving all disciplines be initiated?
- Climate change: What is the atmospheric and oceanic evidence in the North Pacific for change during the last few hundred years?
- Fishery oceanography: How do changes in the ocean environment influence the abundance and distribution of fish and shellfish stocks?
- Environmental quality: What is the evidence for large-scale anthropogenic effects in the region?

Review papers will be prepared for each of the topics, as will be national papers summarizing ongoing research. The outcome of this workshop should be an important contribution to the development of the scientific program of PICES.

# *The Alaska Sea Grant College Program*

## *At Home in the North*

RON DEARBORN

Each of us views our home, our town, our state differently from people who live elsewhere. Each of us develops a unique perspective from daily association with our local environments and resident cultures. With a resident program in each coastal state, NOAA's national network of Sea Grant College Programs clearly enjoys an advantage in marine research and information transfer. NOAA's Sea Grant program at the University of Alaska-Fairbanks is a good example.

Among Sea Grant programs the University of Alaska's program is of average size. Yet it is asked to cover 54% of the U.S. coastline, a distance greater than the circumference of the earth. Spreading seaward from our coast is 74% of the nation's continental shelf, which supports a diversity of life that is as varied as it is important. In 1989 more than four billion pounds of seafood were hoisted from Alaskan waters and sent to markets throughout the world. More than \$500 million is contributed to the nation's international balance of payments by Alaska's seafood.

Additional important resources are provided by this nation's Arctic state. Twenty percent of the nation's crude oil is pumped 800 miles through a steel pipeline that stretches from Alaska's northern coastal plain south across two mountain ranges to Valdez, a small town nestled amidst the coastal mountains. This unassuming town also happens to be the nation's largest domestic cargo port in terms of tonnage shipped. Oil from Alaska heats our nation's homes, powers our automobiles, propels our planes and is made into millions of items all of us use every day. Each loaded tanker leaving Prince William Sound transits fishing grounds of Alaska and passes along the coast of Canada and each of the western coastal states.

In addition to its northern location, Alaska's Sea Grant College Program is defined by its university base. Universities are in the knowledge business, discovering knowledge through research and delivering knowledge to students in the classroom and to constituencies off campus. Four research categories are the backbone of the Alaska Sea Grant College Program, complemented by marine advisory and communications activities. These are Fisheries Oceanography, Resource Biology, Resource Economics, and Technology and Food Science.

### *Fisheries Oceanography*

Debate within the marine scientific community has for some time focused on the relative impacts of environmental change and fishing activity on fish stock abundance. Fisheries resource managers generally agree that dramatic improvements in stock predictions will not be gained without a better understanding of how changes in ocean climate affect recruitment of fish stocks.

Alaska is a logical location to pursue fisheries oceanography. Most global change models predict that the greatest change will occur at 55 degrees latitude, the latitude of the central Gulf of Alaska and the Bering Sea. But even without significant global change, observations in the Bering Sea, which because of its relatively shallow depth is strongly influenced by atmospheric signals, show significant temperature changes within any decade. Findings also indicate fluctuations in fisheries stock structure and abundance. For example, Sea Grant-supported analyses of oceanographic time series correlated with fisheries time series of pollock, halibut and salmon, research conducted by H.J. Niebauer and T.J. Quinn II indicate a striking connection between ocean climate and fisheries recruitment. These climatic and biological factors make continued study of climate change and fisheries production crucial to preserving the region as one the great fisheries of the world.

With its strong faculty of fishery scientists and oceanographers, the University of Alaska-Fairbanks, School of Fisheries and Ocean Sciences, is a leader in this emerging discipline. Analyses by UAF researchers of fisheries and oceanographic variables in the Bering Sea have provided important information and raised new questions about

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*Alaska Sea Grant researchers attaching a float to a dead gray whale found on the Copper River Delta of Prince William Sound, Alaska. They were conducting beach surveys and necropsies of dead marine animals to identify possible causes of death, such as gunshot and gillnet wounds and other man-induced and natural causes of death.*





*A 256-pound halibut being moved to the processing line at Cordova, Alaska, processing plant during a spring 1990 halibut opening. Halibut accounts for about 6% of the total value and volume of Alaska's annual seafood harvest.*

how environmental change influences fisheries recruitment. Similarly an Alaska Sea Grant-funded cooperative study with the Prince William Sound Aquaculture Corporation and the Alaska Department of Fish and Game is providing valuable fisheries oceanographic information to the nation's largest sea ranching operations. The results will ensure greater early ocean survival of salmon fry. Already 30 million hatchery salmon return each year to Prince William Sound.

### *Resource Biology*

Alaska's marine resources dwarf those of any other state. Yet our knowledge of those resources is not proportionally better than for marine re-

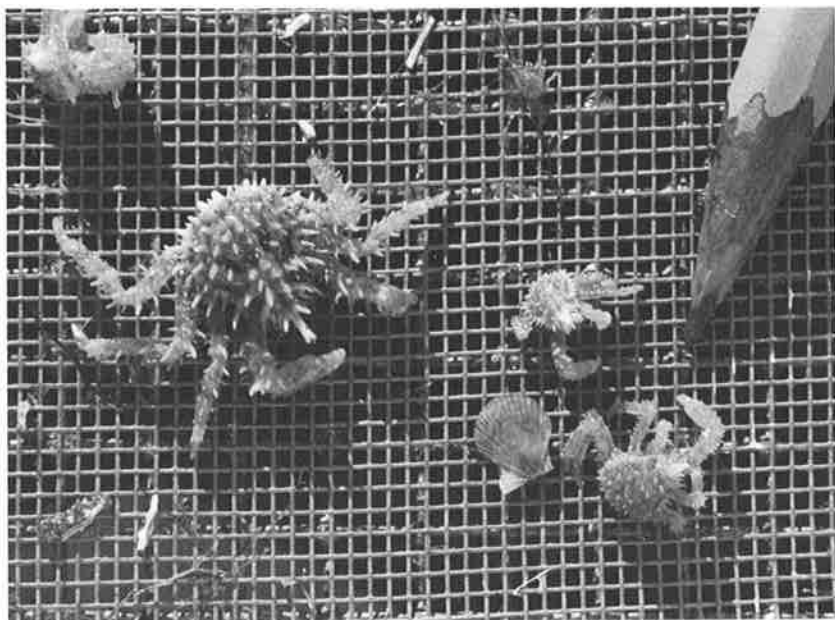
sources at lower latitudes. An emphasis on resource biology is needed to help the nation maintain effective stewardship of Alaska's marine resources. Sea Grant is a partner in this important work. It is in the program area of resource biology that the interplay of research, advisory services and communications, together a hallmark of NOAA's Sea Grant College programs, is so visible in its Alaska-based program.

The Lowell Wakefield Symposia series, initiated by Alaska Sea Grant in 1983, consistently brings together national and international scientists to compare notes, debate ideas and lay the groundwork for targeted research on questions critical to resource management. In October 1990, scientists from nine nations addressed issues involving herring, including early life history, migration and transport, population biology, stock assessment and methodology, population dynamics, management, and human uses and impacts. Proceedings from this symposium and others on crab, pollock and other fisheries are popular references used by the region's academic and government scientists. Sea Grant research on pollock and flatfish energetics, on the size of crabs at sexual maturity or terminal molt, and on herring recruitment, among other projects, have been targeted because of the interchanges at Lowell Wakefield symposia. Government research has realized similar benefits.

Over recent decades there has been a significant migration of the U.S. population to the coastal zone, and demographers predict the trend will continue. Indeed, a recent NOAA report predicts that Alaska's coastal population will more than triple by the year 2010. This migration has already resulted in many citizens becoming aware of the oceans and the resources within. One of the marine resources that has captured the imagination of a broad spectrum of these citizens is marine mammals. Unfortunately our scientific knowledge of marine mammals has not kept pace with the growing public interest nor with the increasing environmental stresses caused by human and natural perturbations. Alaska is home to a large portion of this nation's marine mammal resources. The Alaska Sea Grant College Program has recently emerged among the leaders in the growing national effort to better understand marine mammals and the issues surrounding this natural resource, and the program will continue its active role.

Three years ago agents of the Sea Grant Marine Advisory Program (MAP) in Cordova rekindled studies of marine mammal interactions with the gillnet fishery on the Copper River Delta with funding from Sea Grant and the U.S. Fish and Wildlife Service. Scientific information and edu-





*A one-year-old king crab (left), two young-of-the-year king crabs and a pink scallop (by the pencil point). It takes 6 to 7 years for a crab to grow large enough for commercial harvest.*

cational materials resulting from that work should help reduce the number of marine mammals incidentally caught by fishermen. MAP has also helped the National Marine Fisheries Service with marine mammal stranding and population survey work, and MAP personnel have developed a scientific research plan and provided training for marine mammal observer activities in Prince William Sound and Unimak Pass. The U.S. Fish and Wildlife Service and the National Marine Fisheries Service have provided funding to Sea Grant for a comprehensive field guide to Alaska marine mammals, which will be used as the primary text in observer training classes and will be distributed to the public.

In March 1991 Alaska Sea Grant hosted an international meeting of marine mammal, seabird, fishery and ocean scientists to address the question: Is food availability causing the declines of some seabirds and pinnipeds off Alaska? The paucity of data clearly challenged the array of scientist, but they nonetheless concluded that a decrease in food availability is a significant cause of the observed population declines. Data seem to indicate that strong temperature changes, especially in the Bering Sea, have contributed to a significant shift of prey fish for both birds and mammals. Previously abundant forage species such as herring, capeline, sandlance and eulachon, which have a high fat content, have been replaced to a large degree by pollock and flatfishes. Differences in the caloric value and life strategies of these prey have changed the availability of food for marine mammals and birds. A conference report will be available from Alaska Sea Grant by the end of this year. The debate on how fisheries policy might fit

into this equation continues. Sea Grant's research role will expand over the coming years.

## *Resource Economics*

Alaska has not outgrown its territorial history, in part because of the large proportion of the state that is controlled by the Federal government, but also because many of the state's institutions have not fully matured. Prior to statehood, Alaska's fishery policy was set by the processing industry in Seattle, Washington. Japanese markets currently influence the profitability of Alaska fisheries. For Alaska to more wisely manage its own resources it must first invest in its institutions.

Increasing the University of Alaska's capability in one of these institutional arenas—fishery economics—has for a decade been a priority of the Alaska Sea Grant College Program. Persistence is paying off. As economics faculty vacancies occur or new positions are created at the University of Alaska, they increasingly are being filled by economists with training and interest in fishery and resource issues. Five faculty, all of whom have joined the University of Alaska in the past three years, have outlined significant research in resource economics that they intend to pursue over the next several years. This is a prime example of how the National Sea Grant College Program, through its state programs, is building the capability of the nation's universities to respond to needs and opportunities presented by our coastal oceans.

## *Technology and Food Science*

Opportunities for adding value to the U.S. fishery without additional pressure on the resource are being bypassed. Because Alaska's contribution to the nation's fish landings dwarf those of other states, it is easy to overlook the huge gap between the realized value of Alaska fisheries and its potential value. This difference exists for many reasons. Some of these reasons are:

- The state's commercial fishing and processing industry each year discards about one billion pounds of fish protein as waste;
- Most of the seafood that Alaska exports undergoes minimal processing;
- Product quality and product form are not as advanced as possible;
- Processing techniques are not as refined as they could be; and
- Harvesting technology needs to be updated to take advantage of underutilized species, especially the flounders; improvements in the aquaculture industry are also needed to lower costs and increase production.



Investments by Alaska Sea Grant in seafood science and technology are providing advances in these areas. Much of this work is accomplished at the University of Alaska–Fairbanks Fisheries Industrial Technology Center (FITC) in Kodiak, Alaska, one of the nation's premier fishing ports. Conceived by Alaska Sea Grant and established in 1981 by the Alaska Legislature, FITC is charged with creating new economic and employment opportunities through seafood product development, processing improvements, seafood quality control, harvesting techniques and training. FITC this year moved into a new state-funded \$8 million research facility, further evidence of Alaska's recognition of the untapped economic potential of the state's offshore commercial fishery and of the state's confidence in the capabilities of university researchers.

Alaska Sea Grant recognized the problem of seafood waste ten years ago and further recognized that the waste could yield economic benefits. A program was begun to create new products and markets for these leftovers. The effort's initial products were used in agricultural feeds. Soon faculty and students at the University of Alaska–Fairbanks Agricultural Experiment Station moved a little closer to home and developed fish-based dog food formulas for Alaska's competitive sled dogs. The national reputation of Alaska's huskies opened the door for Alaska fish byproducts to contribute to production of the 5.9 million tons of pet food sold in the United States each year, products that are worth \$6.8 billion. Here, Alaska Sea Grant researchers, stimulated by a local problem, developed a local solution and consequently contributed economic benefits in a national (and in fact international) setting: One of the herring-based dog foods is now exported to Norway, a feat akin to shipping coal to Newcastle.

Other Sea Grant research has contributed to the development of U.S. technology for producing surimi and to better understanding of the unique northern fishes that call for special approaches to seafood preservation. Much of this research has focused on salmon quality.

### *Honoring Its Roots*

With its modest funding, Sea Grant has been remarkably successful nationwide, thanks to the vision of the founders of the program in the U.S. Congress, who set up an institutional balance between the state universities and the Federal government. This structure successfully blended the benefits of local resident programs and management with the central oversight of a government agency.

With homes in each coastal state and Puerto Rico, Sea Grant can accurately target its research. And just as important, the Sea Grant network understands where and how to target its educational programs, especially those designed to benefit local citizens.

While NOAA's \$1.2 million annual investment in the Alaska Sea Grant College Program is not adequate to address all the challenges and opportunities we face, the modest investment is wisely and efficiently used, because Alaskans who are in touch with the needs of the North share in Alaska Sea Grant's management.

Many perceive Sea Grant as a research program, and research certainly is the backbone of the program. But the soul of the program is its connections and interactions with local and national constituencies. Taken together, the dual investment in targeted research and communicating, both listening and enlightening, sets Sea Grant apart.

### *The First Meeting of the International Arctic Science Committee*

*Additional information on  
IASC activities can be  
obtained from the Polar  
Research Board, National  
Academy of Sciences, 2101  
Constitution Ave. NW,  
Washington, D.C. 20418.*

The International Arctic Science Committee (IASC) was conceived to facilitate cooperation in all fields of Arctic science, and its establishment last year was unprecedented in bringing together all Arctic countries to agree on the need for a non-governmental organization for this purpose. In August 1990, the Founding Articles were signed by representatives of the adhering organizations from the eight Arctic countries (see *Arctic Research of the United States*, Fall 1990, p. 65–69). The National Academy of Sciences (NAS) serves as the U.S. adhering body, and within the NAS, the Polar Research Board provides the means for U.S. participation in IASC. Norbert Untersteiner, chairman of the Atmospheric Sciences Department, University of Washington, was appointed by the NAS as the U.S. representative to the IASC Council, the main scientific advisory body, and he serves concurrently as the vice-chairman of the Polar Research Board. An appointment of the U.S. representative to the IASC Regional Board, the IASC group organized to consider general Arctic problems and the special interests of Arctic countries, is forthcoming.

The first meeting of the IASC Council was held in Oslo, Norway, in January 1991. A number of significant steps resulted from the meeting. Six new countries were admitted (France, Germany, Japan, the Netherlands, Poland and the United Kingdom). Within each country, a scientific organization was identified as an adhering body.

After much discussion of scientific needs and programs, only one working group was established, focusing on global change studies in the Arctic. Gunter Weller, University of Alaska–Fairbanks, will serve as the chairman. The group will organize a workshop in conjunction with the next IASC Council meeting. The International Council of Scientific Unions' International Geosphere–Biosphere Program (IGBP) and the World Meteorological Organization's World Climate Research Program (WCRP) have been notified of this activity. The working group was given a boost at a recent meeting of the IGBP Start Steering Committee when it was agreed that the Arctic should get early attention for a regional program and that IASC should be the focal coordinating body.

The Council agreed that some activity related to the human, social and medical sciences was needed but that further evaluation of research pri-

orities and identification of specific areas for IASC involvement would be necessary before the Council could agree on the terms of reference for a working group. An ad hoc working group, chaired by Marianne Steinbeck (Canada), was invited to develop a proposal for consideration at the next Council meeting.

Based on recommendations of a joint U.S.–Canadian paper, an ad hoc group was established to consider compilation of an annotated directory of Arctic data bases and systems. The Polar Research Board has suggested close interaction with the Interagency Arctic Research Policy Committee regarding the Arctic Environmental Data Directory.

The Council recommended that further consideration be given to the development of an inventory of major scientific activities to encourage scientific exchange and cooperation. The Polar Research Board chairs this effort and will discuss options at its next meeting.

The Council noted that a relationship between IASC and the Finnish Initiative, which culminated in the signing of an Arctic Environmental Protection Strategy, could be productive. The IASC chairman wrote to the organizers and subsequently was invited as an observer to the concluding session in Rovaniemi, Finland, in June.

Administrative structures, operating procedures and leadership group were identified. As a result of IASC Council recommendations, Odd Rogne was selected to serve as the Executive Secretary. The Secretariat was established in Oslo, Norway. Rules and procedures for conducting IASC activities were approved in principle until the next meeting. An Executive Committee was appointed (F. Roots, Canada, chairman; I. Gramberg, U.S.S.R.; G. Hempel, Germany; A. Olmholt, Norway; and H. Untersteiner, U.S.A., vice-chairman) with an initial charge to write a document identifying the criteria for selecting scientific topics, for forming affiliations with other organizations and for seeking funding for IASC activities.

The next IASC Council meeting is tentatively scheduled for 27 April–1 May 1992 in Iceland. The first IASC Executive Committee meeting was held in Oslo, Norway, 8–10 September 1991. Discussion of the IASC scientific agenda was a main item at the Polar Research Board meeting in Washington, D.C., 21–23 October 1991.

*Prepared by Sherburne B.  
Abbott, Director, Polar  
Research Board.*

# Arctic Activities under the U.S.–U.S.S.R. Agreement on Cooperation in the Field of Environmental Protection

*Prepared by Jerry Brown,  
Co-Chair, Area X, and  
former Head, Arctic Staff,  
National Science Foundation*

The Thirteenth Meeting of the U.S.–U.S.S.R. Joint Committee on Cooperation in the Field of Environmental Protection was held in Moscow, February 18–22, 1991. The status and implementation of activities of all working groups and projects were reviewed, and plans were prepared for 1991 exchanges. The official memorandum was signed in Moscow on April 22, 1991, by the Co-chairmen of the Joint Committee, N.N. Vorontsov, Minister of the Environment, and William K. Reilly, Administrator, U.S. Environmental Protection Agency.

The agreement consists of 13 project areas, the newest of which are on information, education and training (XII) and pollution prevention (XIII) (see *Arctic Research of the United States*, Spring 1988, p. 53–54 for additional background). Area X: Arctic and Subarctic Ecosystems is totally committed to northern activities, while several other areas have specific projects devoted to Siberia, the Far East, Alaska and the Bering and Chukchi seas. Major activities and accomplishments for these northern activities are summarized below.

The National Park Service under Area IV is providing the U.S. leadership to establish the International Park in the Beringian Region. The NPS has designated the Bering Land Bridge National Preserve as the U.S. portion of the park. The Soviets hosted an international meeting in August 1991 in Provideniya to unveil plans for its part of the park. Essentially the entire Chukotka Peninsula was identified, including seven areas deserving special protection. The conference was attended by U.S. participants representing Areas IV, X and XI, the National Audubon Society and the North Slope

Borough. In addition, a number of technical and administrative exchanges took place in 1991 under Area IV, including activities on preservation of cultural sites.

Area V: Protection of Nature and Organization of Reserves is under the leadership of the Fish and Wildlife Service, which sponsors exchanges of American and Soviet specialists in the areas of rare and endangered fauna and flora, migratory birds, marine mammals, fish husbandry, and terrestrial and marine ecosystems. Among the major 1991 exchanges with Alaska and “lower 48” counterparts were studies of raptors in the Kola Peninsula and the Far East, polar bear migration and distribution patterns in the Wrangel–northern Chukchi Peninsula region, walrus surveys in the Bering and Chukchi seas, research on fur seals on the Pribilof Islands, comparative research on flora and vegetation, northern migratory waterfowl studies between Alaska and the Soviet Far East, ichthyology and aquaculture, and collection and processing of remotely sensed data. This last activity included classification, analyses and verification of sea ice maps and the successful completion of the trial downlink of the U.S.S.R. “Ocean-II” satellite with the Geophysical Institute in Fairbanks.

Areas VI, VII and XI involve additional activities in the Bering–Chukchi seas. The Coast Guard (VI), representing the U.S. on the Joint Soviet–American Task Group, continues to facilitate measures against pollution under emergency situations. The Fish and Wildlife Service (VII) coordinated several exchanges of specialists to complete reports on the earlier Bering–Chukchi cruises and to plan the joint 1992 expedition. The Council on Environmental Quality (XI) continued discussions on environmental law and assessment and legal regimes related to the Bering Sea region, and it met with its counterparts during the Provideniya meeting on Beringia. The proceedings of the 1991 Conference on the Shared Living Resources of the Bering Sea Region was published and is available from CEQ.

Area VIII on climate is organized and coordinated by the National Climate Program Office. Northern activities continued on models of the distribution of permafrost, sampling and analysis of lake sediments across the Beringia land mass, ozone measurements and a variety of paleo- and atmospheric modeling efforts. Planning for atmospheric chemistry programs included projects on stratospheric ozone, Arctic haze and trace gas fluxes. The report *Cooperation in Climate Research:*

*U.S. and Soviet participants  
in August 1991 field tour of  
the Chukotka Peninsula.*



*An Evaluation of Activities Conducted under the U.S.-U.S.S.R. Agreement for Environmental Protection since 1974* was published in 1990 and is available from the NCPO.

Area X: Arctic and Subarctic Ecosystems consists of six projects and over the past several years has been coordinated through the National Science Foundation. A brief report of each activity follows.

*Environmental Protection for Oil and Gas Developments in Permafrost Regions:* Three U.S. representatives attended a conference in Syktvkar (Polar Urals) on northern development and restoration. Comparative geobotanical and revegetation field studies continued on the Yamal Peninsula. Two Gas Ministry delegations were hosted in Alaska while attending the Society of Petroleum Engineers' Arctic engineering conference in Anchorage and the University of Alaska heat transfer conference in Fairbanks. After visiting sites in Alaska, two Soviet permafrost mapping specialists participated in a joint U.S.-Canadian-Soviet meeting on permafrost mapping.

*Rational Development of Northern Landscapes and Prevention of Negative Impacts Caused by Critical Loads:* A workshop on rational development was held at Dartmouth College in May 1991 and was attended by six Soviets from the Institute of Systems Studies and Goskomprirroda. The U.S. reviewed environmental approaches in Alaska, and the Soviets discussed West Siberia developments. A summary paper is in preparation. Several Soviets were hosted (XI) in the U.S. while attending an environmental assessment meeting and presented seminars on the Soviet approach to the EIS process. U.S. scientists and engineers attended several permafrost seminars, including one on foundations and mining in Norilsk and another in Anadyr on ground ice and northern development.

*Ecological and Cultural Studies in Arctic and Subarctic Regions:* Plans for joint projects were further developed in Moscow during a workshop on panarctic biota and a workshop in Michigan on the International Tundra Experiment (ITEX). A Soviet Academy geobotanist visited San Diego State University and the University of Colorado to discuss ecological and GIS projects and present lectures. Three Soviet biologists conducted North American studies with a University of Washington field team in preparation for comparative investiga-

tions on the Taimyr Peninsula. In conjunction with the Man and the Biosphere (MAB), a workshop on Arctic vegetation was organized at the University of Colorado for March 1992. This project area is working in close cooperation with the MAB Northern Sciences Network and its office at the Arctic Center, University of Lapland, Rovaniemi, Finland. A U.S. social scientist is spending the academic year in Rovaniemi to improve circumarctic communications and research planning.

*Monitoring of Cryospheric Processes under Conditions of Global Change:* Project activities are primarily aimed at coordinating with other international activities, including permafrost mapping and data activities under Area VIII, IGY Data Center activities at Boulder, Colorado, IPCC Working Group II on the cryosphere, the USGS-led Arctic Environmental Data Directory, several glaciological and permafrost field projects in Alaska, and data and mapping activities of the International Permafrost Association.

*Structure, Function and Preservation of Arctic and Subarctic Ecosystems in the Bering Region:* Activities in this area primarily focused on future involvements with the new International Arctic Center in Magadan and development of joint projects and programs. Several cooperative activities took place, including a joint expedition to Chukotka and St. Lawrence Island to compare glacial and marine sections and a workshop on Beringia in Fairbanks. The National Audubon Society conducted field studies in Chukotka and developed plans for education programs.

*Arctic and Boreal Bioaccumulation of Anthropogenic Airborne Contaminants:* This new project with Bowling Green State University builds on similar research in Alaska sponsored by the Environmental Protection Agency. During the summer a U.S. team sampled areas in the Kola Peninsula and the Polar Urals. In a cooperative activity, a University of Alaska project involving an Earthwatch team sampled the snow cover of the Kola Peninsula for nitrogen and sulfur deposition.

The 1991 memorandum and the 1990 progress report are available from William Freeman, Executive Secretary, U.S.-U.S.S.R. Environmental Agreement, U.S. Environmental Protection Agency. The next Joint Committee Meeting is scheduled for early February 1992 in Washington, D.C.

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## *U.S.-U.S.S.R. Agreement on Cooperation in Ocean Studies*

On December 18, 1989, U.S. and Soviet representatives initialled an Agreement on Cooperation

in Ocean Studies, the Ocean Studies Agreement. This negotiated agreement was subsequently



signed by Secretary of State James Baker and Soviet Foreign Minister Edward Shevardnadze on June 1, 1990, in the course of a Presidential summit meeting in Washington. The new agreement is a continuation of the World Ocean Agreement, which was signed by the two nations in 1973 but has been inactive since the Soviet invasion of Afghanistan in 1979. The principal difference between the new agreement and the earlier one is the addition of an annex on protection of intellectual property rights. Four research projects, already approved under the earlier World Ocean Agreement, were continued under the new Ocean Studies Agreement. The lead U.S. agency for management purposes is the National Oceanic and Atmospheric Administration, while the lead Soviet agency is the State Committee for Science and Technology.

The first meeting of the Joint Committee on Cooperation in Ocean Studies was held in Moscow on September 14–17, 1990. The U.S. delegation was led by Dr. John A. Knauss, Undersecretary of Commerce for Oceans and Atmosphere; the Soviet delegation was led by Academician L.M. Brekhovskikh, member of the Presidium of the U.S.S.R. Academy of Sciences and chairman of the Academy's Committee on the World Ocean. The Joint Committee approved continuation of research projects on Southern Ocean dynamics, mid-Atlantic ridge crest processes, geochemistry of marine sediments, and Arctic erosional processes and gas hydrates. It also approved new research projects on diving physiology and circulation of the Chukchi and Bering seas.

After the formal sessions at the Joint Committee meeting, the U.S. delegation visited the Shirshov Institute of Oceanology in Moscow; the Arctic and Antarctic Research Institute, the Department of Navigation and Oceanography, and the Testing Center of the Naval Search and Rescue Service in Leningrad; and the Marine Hydrophysical Institute and Institute of Biology of the Southern Seas in Sevastopol.

In the course of the Joint Committee meeting, members of the Soviet delegation presented new research proposals dealing with near-bottom oceanology, geological and geophysical transects, and orientation and communication of marine mammals. The Soviets had earlier proposed joint Arctic research in oceanography, climate studies, and geological and geophysical research.

On the average, about 25,000 km<sup>3</sup> of Pacific waters pour northward through the Bering Strait every year, but with a very large seasonal and interannual

variability. Much of this water upwells onto the shelf in the northwestern Bering Sea, and it carries a large nutrient load that fertilizes the northern Bering and Chukchi seas, supporting some of the highest biological production rates in the world ocean. The northward flow of the Pacific waters also markedly influences the physical state of the ocean, including the ice cover, exchanges with the atmosphere, and the upper ocean structure over the majority of the Polar Basin. The latter probably has profound climatic consequences.

Because the physical system is divided between the Exclusive Economic Zones of the U.S. and U.S.S.R., neither the biological nor the physical regime can be understood without extensive work on both sides of the U.S.–U.S.S.R. convention line. The Pacific Marine Environmental Laboratory of NOAA therefore initiated a comprehensive joint research program with the Arctic and Antarctic Research Institute in Leningrad in 1990. The goals of the program are to define the shelf circulation and its controlling dynamics, ascertain in detail the means by which the high biological production is supported, determine the transformation on the shelf of Pacific waters and the means by which they are exchanged with the Arctic Ocean, and elucidate the dynamics and thermodynamics of the interactive ocean–ice–atmosphere system. The work during 1990 included a two-ship field program involving the deployment of 23 long-term instrumented moorings, the occupation of well over 200 hydrographic stations, and the establishment of a number of drifting buoys and coastal meteorological stations. These joint efforts were scheduled to continue in 1991, again with two ships, and with expanded participation by the University of Alaska.

Several times during the visit of the U.S. delegation to the U.S.S.R., senior Soviet officials brought up the subject of their role in the Ocean Drilling Program (ODP). They urged Dr. Knauss to press responsible parties in the U.S. to allow Soviet participation soon, adding that the response would affect possible cooperation in other areas such as the Arctic. Now that the U.S.S.R. is being admitted to the ODP, joint U.S.–U.S.S.R. Arctic research may become easier to arrange.

Our general impression, formed especially in the course of beginning new projects in diving physiology and circulation of the Bering and Chukchi seas, is that Soviet institutions are making a sincere effort to promote and carry out joint research within the limits of their financial resources.



## *U.S.–Iceland Workshop on Scientific Cooperation in the North Atlantic*

Forty scientists from the United States and Iceland met at a workshop on October 22 and 23, 1990, in Baltimore, Maryland, to discuss their scientific interests in the North Atlantic region. Discussions focused on further developing existing collaboration (e.g. fisheries and geology), as well as initiating new cooperative projects (e.g. comparative ecosystem studies). General areas of mutual interest are outlined below. In a number of cases, specific follow-up activities were identified, including a meeting in Iceland in May 1991 to further explore common interests. The workshop was organized by the National Oceanic and Atmospheric Administration (NOAA) on behalf of the U.S. government.

In his opening remarks, Dr. Arnthor Gardarsson, head of the Icelandic delegation, expressed the support of his government for establishment of a Center for Environmental Research in the North Atlantic (CERNA). Plans for this international center will be discussed further in 1991.

### *Physical Process Studies Leading to Models of the North Atlantic*

The patterns of circulation and stratification in the waters surrounding Iceland are key elements of any models for regional biology and chemical air–sea exchanges, as well as in global climate models (through their relations to air–sea–ice interaction and deep water formation processes). Efforts in ocean modeling have not focused on resolving the process scales that are likely to dominate in this region. Therefore, close cooperation is proposed to develop appropriate models and the data bases required to test them and to use them in a prediction mode. In the broadest sense we are dealing with

- How ocean–atmosphere–ice interactions affect the physical conditions and the biological environment in the region from the Greenland Sea to the Polar Front south of Iceland; and
- How the subpolar ocean functions as a dynamic element of the global climate system.

To address such questions it will be necessary both to conduct observations of the actual processes and to develop the appropriate model framework for data assimilation and process prediction. While a number of special experiments such as the Greenland Sea Project and the Mar-

ginal Ice Zone Experiment (MIZEX) have addressed related questions, we feel that a long-term commitment to an observing program will be essential if models are to be adequately tested and verified.

The need to improve and test ocean models for high-latitude aspects of the physical climate system has been recognized in the WCRP–WOCE context, specifically in the Atlantic modeling program, as well as by the U.S. NOAA Atlantic Climate Change Program, which is a component of NOAA's Global Change Initiative. This need is also reflected in the ICES initiative of Cod and Climate Change, where it is seen as a necessary link in a chain of process models that leads all the way to process modeling on the scales relevant to biological events in the ocean.

One critical element of the conceptual framework is a northern North Atlantic physical model. Existing models treat the northern North Atlantic (within the 500-m contour) too crudely to be used to predict the effects of climate change locally on Iceland or coastal regions of the east coast of the U.S. Several specific research activities identified above would help to improve physical models of the Atlantic, including the relatively shallow northern region.

As a result of accelerating rates of release of industrial CO<sub>2</sub> into the atmosphere during the past 100 years, the concentration of atmospheric CO<sub>2</sub> has increased by about 25% from the preindustrial value of about 280 ppm to the present value of about 350 ppm. The northern North Atlantic Ocean and the adjoining seas, including the Labrador, Greenland, Norwegian and Iceland seas, play important roles in processes regulating the concentration of atmospheric CO<sub>2</sub>.

Current bilateral research activity on carbon dioxide is limited to the monitoring of surface water chemistry at two stations located north and west of Iceland. Although we have learned much about high-latitude CO<sub>2</sub> uptake processes, this is not enough to assess the amount of CO<sub>2</sub> taken up by northern high-latitude waters. Accordingly a more extensive program should be undertaken in the future to include:

- Seasonal and interannual monitoring of CO<sub>2</sub> and its related properties in surface waters of the high-latitude regions in the North Atlantic;
- Yearly observations of CO<sub>2</sub> and its related

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properties in the subsurface waters representing the outflow off the Greenland-Iceland-Faroes sill; and

- Once every 5–10 years, measurements of CO<sub>2</sub> and its related properties repeated along a long north-south section similar to that investigated during the TTO program in 1981. These time series data will be critically important for testing the reliability of predictive computer models.

To realize these observational programs vital to the assessment of the globally significant CO<sub>2</sub> problem, a broader-scale cooperative program encompassing the U.S., Icelandic and Scandinavian scientific communities is required. Iceland will occupy a pivotal position in executing this multinational program due to the demonstrated capabilities of Icelandic scientists and Iceland's geographic location, which will conveniently serve as the hub of seagoing activities. These proposed activities are compatible with the NOAA Ocean Carbon Program.

### *Comparative Ecosystem Studies*

Bilateral cooperation between the U.S. and Iceland should serve as a vehicle for enhancing the cooperation that already exists under the umbrella of broad international agreements, such as the International Council for Exploration of the Sea (ICES), and for encouraging initiatives of individual scientists from both Iceland and the U.S. It should also expand U.S. national initiatives that are of interest to Iceland, such as the NSF Global Ecosystems (GLOBEC). In particular, the ICES plans for an international study of Cod and Climate Change (CCC) should be strengthened by bilateral cooperation.

The conceptual model for CCC can be used as a mechanism for integrating several research interests. CCC is a prototype for research on the effects of global- or basin-scale climate change on local environments and ecosystems. The conceptual framework of a hierarchy of cascading, linked models ranging from the global climate scale to the scale of fundamental processes, such as trophic interactions between organisms, applies equally to research on cod, zooplankton, primary producers, higher organisms, ice edge processes, air-sea exchange of carbon and nutrient cycling.

Progress in marine research can be enhanced by comparing the various dynamic states among marine ecosystems. The approach of studying critical processes controlling the structure and function of biological communities on a regional basis is becoming more widely accepted by ecologists and

marine scientists. The approach provides a framework for considering large marine ecosystems as units for conservation and management of living resources. Large marine ecosystems are extensive areas of ocean space of more than 200,000 km<sup>2</sup> that are characterized by unique bathymetry, ocean dynamics and productivity within which marine populations have adapted reproductive, growth and feeding strategies and that are subject to dominant forcing functions such as exploitation, pollution and natural perturbations. Many of the large marine ecosystems on a worldwide basis are being subjected to stress from various forms of human interference or uses, including heavy exploitation of renewable and nonrenewable resources and pollution against a background of global change.

The concept of large marine ecosystems defines the unit of study on the order of thousands of kilometers in scale, with regard to fish and fisheries yields, and represents energy flow from a top-down approach to factors determining variability. In this approach, large-scale climatic or environmental changes are examined in relation to multi-decadal fisheries-yield patterns of marine ecosystems. Changes in the fish communities of large marine ecosystems can trigger a cascade effect involving higher trophic levels of marine mammal and bird populations, lower trophic levels of phytoplankton and zooplankton, and the economies dependent on the resources of the ecosystems. There are a number of scientific questions that are central to the rational management of marine communities, all of which revolve around the question of sustainability.

### *Atmospheric Chemistry*

There is relatively little knowledge about atmospheric chemistry processes in the high-latitude North Atlantic. Most programs have focused on the midlatitudes because of immediate interest in the impact of pollution from North America and Europe on the adjacent oceanic regions, or they have focused on the polar regions because of evidence of large quantities of pollutants being transported from Eurasia directly to the Arctic. Meteorological studies and global-scale chemical transport models suggest that Iceland is located in one of the major transport paths for pollutants that are emitted in the midlatitudes in North America and Europe. The path is a consequence of the year-round presence of the Icelandic low-pressure center, which tends to bring in air from North America on southwesterly winds, and storm systems, which bring in air from northern Europe on southeasterly winds.

The Iceland region is also interesting from the standpoint of natural atmospheric chemistry processes. Of particular interest is the role of the ocean in the atmospheric sulfur cycle. A number of marine phytoplankton species (especially *Phaeocystis pouchettii*) are known to produce dimethylsulfide, some of which is released to the water. The dimethylsulfide diffuses to the atmosphere where it is oxidized to a number of species, the most abundant product being sulfate aerosol. Sulfate aerosol plays a critical role in radiation and cloud formation processes and is believed to be a major factor in controlling the atmospheric radiation balance over most oceanic regions. Dimethylsulfide emission rates appear to be linked to primary productivity. Because Iceland is located in waters that are among the most productive in the world, it is an ideal location to study the factors that affect the life cycles of the sulfur producers, dimethylsulfide emissions to the atmosphere, and subsequent atmospheric chemistry. Of particular interest are the production rates in ice-edge regions. Improving knowledge of the factors controlling the chemistry of the polar atmosphere will lead to improved understanding of the paleoclimatic record obtained from snow and ice cores.

## *Seafloor Spreading and Hydrothermal Venting*

The geologically unique Icelandic region is an ideal natural laboratory for studying the processes of crustal accretion and underlying mantle dynamics. The area marks transitions from a subaerial hotspot—volcanic province sitting on a spreading center (Iceland) to submarine hotspot-dominated midocean ridges (the Kolbeinsey and Reykjanes ridges to the north and south). These transitions are associated with changes in magmatic, tectonic and hydrothermal processes along the ridge and with major deep-seated geochemical and geophysical discontinuities in the earth. The increased water depth, and therefore pressure along the ridges, also affects the geochemical and physical expression of volcanic and hydrothermal activity.

The Icelandic region has played a crucial role in the paleoceanography of the North Atlantic. The Greenland–Iceland–Faroes transverse ridge acts as the gateway for nutrient-rich bottom water from the Arctic to enter the North Atlantic. The geologic evolution of this region has had important paleoclimatological effects, and the region continues to play an important role in North Atlantic circulation and productivity today.

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## *Northern Forum Update*

The Northern Forum is an international organization comprising regional northern leaders and additional representatives from businesses, universities, special interest groups and the private sector. It will address a broad range of concerns, including health care, environmental pollution, education, transportation and scientific innovation in the North.

The initiative for a permanent international organization to address these issues arose from the Governors' Summit at the Third Northern Regions Conference in Anchorage, Alaska, in September 1990 (see *Arctic Research of the United States*, Fall 1990, p. 90–91). Leaders from 11 northern nations and Alaska attended, including Finland, Norway, Denmark, Sweden, Greenland, U.S.S.R., Canada and the northern regions of Korea, China and Japan. The resulting Statement of Intent formalized their desire for a permanent organization to act as a mechanism for the regular exchange of ideas and to improve the quality of decision-making affecting the lives of northerners.

What distinguishes this organization is the uniquely northern perspective of its cultural, economic development, environmental, political and

social concerns. The Northern Forum offers the opportunity for government-to-government support and cooperation in solving common problems and participating in joint opportunities. It also offers northern regions a collective international voice and potential affiliation with the United Nations.

Alaska's Governor Walter J. Hickel invited northern leaders to return to Alaska on May 31, 1991, to begin developing the structure and strategy of this international organization. The resulting Northern Forum Agreement evidences their support and the identification of an interim secretariat and an interim board to continue this effort.

A meeting of the interim board was held August 20 and 21, 1991, at Alaska Pacific University, Anchorage. This meeting involved a thorough review of draft documents, including bylaws. Membership and possible project topics were also discussed. A summary of interim board recommendations has been prepared and will be presented to the founding regional members. These recommendations are embodied in the draft Founding Documents and include the following key points:

- Establish a permanent organization—to be

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known as the Northern Forum—to represent the northern region and its interests.

- Define a northern region as an area meeting the basic attributes of the North, such as climate, resource dependence, population and others. All regions involved in the Third Northern Regions Conference are eligible to be founding members. All others must be approved by the voting members.
- Permit only states and regions in the North to be voting members, have the right to approve new members and select priority projects for the Northern Forum. Nonvoting membership is open to any interested government, organization, individual or business.
- Give each voting member a seat on the Board of Directors of Northern Forum Inc., the secretariat of the Northern Forum.
- Fund the Secretariat through a \$10,000 annual fee for each voting member. Other monies needed to fund the organization will be assessed on a sliding scale, based on each region's gross regional product. In-kind payments are possible in some cases. Nonvoting members are also to be assessed a \$10,000 annual fee.
- Require priority project proposals to be ap-

proved by voting members. Costs for the projects are to be borne only by project participants.

The Founding Meeting was held on November 6–8, 1991, in Anchorage. Governors or representatives from the following northern regions attended: Alaska; Magadan; Kamchatka; Chukotka; Khabarovsk; RSFSR; Jewish Autonomous Region; Trondelag, Norway; Yukon, Canada; Lapland, Finland; Hokkaido, Japan; Heilongjiang, China; Korea; and Mongolia. The following projects were presented at the Founding Meeting:

- Wildlife Studies (Japan)
- Air and Water Pollution (Japan)
- Northern Sea Route (Trondelag, Norway)
- Capital Formation (Yukon, Canada)
- Korea's Involvement (Korea)
- Human Ecology (Magadan and Chukotka)
- East–West Air Routes (China)
- Circumpolar Health (Alaska).

The Northern Forum offers the opportunity for many diverse organizations to lend their knowledge and talents by introducing and developing joint projects. The State of Alaska, Department of Commerce, Office of International Trade is participating as the interim secretariat and can be contacted for further information.

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## *Beringian Quaternary Terrestrial Research*

With increasing opportunities to conduct joint research between Alaska and the Far East, the number of field projects, meetings and workshops increased in 1991. The following reports on several workshops and related field activities focused on the paleo-environments and paleoclimate of Beringia and conducted under both the U.S.–U.S.S.R. Environmental and Science and Technology Agreements.

### *Summer Workshop, Fairbanks*

The response of terrestrial environments to climatic changes of the Quaternary is central to understanding the recent evolution of landscapes and biota and to predicting the effects of future climatic change. Beringia, the unglaciated region encompassing eastern Siberia, the Soviet Far East, Alaska and northwest Canada, contains long records of Quaternary environmental change at high latitudes. However, the division of Beringia by the U.S.S.R.–U.S. boundary has long imposed serious constraints on east–west synthesis of Beringian paleoenvironmental studies, which until

recently have been carried out on the two sides in virtual isolation.

Field work, meetings and a workshop were convened in Fairbanks during May and June 1991 to bring together Soviet and American scientists studying the terrestrial environmental record of Beringia. In particular, it encouraged the mutual exchange of approaches and methodologies in field science, which is critical to paleoenvironmental studies and reflects culturally based differences—as do other aspects of science.

The main achievements of the workshop were:

- A substantial four-week joint Soviet–American field study at Gold Hill (Fairbanks);
- A four-day meeting attended by American and Soviet scientists;
- The identification of current differences in scientific approach and of potential barriers to international, interdisciplinary studies that must be overcome;
- Identification of key research topics and recommendations for joint action at administrative and scientific levels to facilitate future joint Beringian research;
- Development of personal contacts and infor-

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mation exchange between American and Soviet Beringian scientists;

- The presentation and discussion of a series of scientific papers on Beringian paleoenvironments, which will be published during the coming year by the University of Alaska; and
- Considerable student participation in both field activities and the meeting.

The following points can be made in comparing research approaches:

- Soviet efforts involve many experts in various fields at important sites. Much time is spent on field work, and complex exposures are studied in detail. On the American side, even the most critical sites are usually studied much less thoroughly.
- Americans involve modern process studies in interpreting sedimentary sequences. They are more aware of paleoclimatic theory and tend to refer more to global standards, such as the isotopic ice volume curves.
- Soviets emphasize biotic systems and biostratigraphy, while the Americans emphasize geology and geochronometry.
- Merging the best aspects of these contrasting approaches should lead to a powerful collaborative effort in Beringian paleoenvironmental studies.

The following future research priorities were identified:

- Considerable progress can be made in pan-Beringian correlation and relative dating using mammalian faunal chronologies developed in the Soviet Union. Mammals of Olyorian age (Late Pliocene–Early Quaternary) first recognized in west Beringia have been discovered in Alaskan and Yukon sites. Further research in micromammalian biostratigraphy should be encouraged in eastern Beringia, as it is the most reliable tool for correlating paleoenvironmental events for periods not covered by “absolute” dating methods.
- A promising multidisciplinary study, which is using a combination of Soviet and American analytical techniques, has been started on the paired late-Quaternary sites at Omolon (Lower Kolyma) and Gold Hill. This has the potential to be continued and expanded.
- Both east and west Beringia contain extensive sand deposits that have the potential to yield much paleoenvironmental information. In particular, a joint Soviet–American study of the Kallerchin Tundra (Lower Kolyma) promises to be profitable.
- Mapping paleodata helps distinguish between broadly synchronous (and hence climatic) patterns and local effects. Horizons such as the

Brunhes–Matuyama transition and the last interglaciation are critical periods for paleoenvironmental studies. For such times, data bases from networks of sites across Beringia should be developed.

- A terrestrial–freshwater amino acid chronology could distinguish between stages 3 and 5, a critical period, and could cover the entire Pleistocene. To build the data base, amino acid dating labs are requesting that fieldworkers contribute collections of molluscs and ostracods, particularly when datable by other methods.

The following structural and administrative needs were discussed:

- A language and communication barrier currently hinders collaboration. Several actions are needed: the community should promote more international transfer of information; Soviets and Americans should be encouraged to write joint review and synthesis papers; Americans studying Beringia should learn Russian; and international exchanges of students and scientists should continue to be fostered.
- Funding agencies, academic institutions and professional societies should recognize the need to support professional development, scientific exchange and information transfer.
- The best results in international cooperation come when good personal relations are built between groups. This kind of workshop is an invaluable vehicle for small-group communication. More should be encouraged.
- Understanding interactions between climate, ecosystems and geomorphic processes requires scientists with interdisciplinary skills. Institutions should encourage the training of interdisciplinary individuals, and multidisciplinary research, which all too often “fall through the cracks” in funding agencies.
- Chronology underpins all Quaternary studies. Several issues must be addressed: more access to AMS radiocarbon facilities is urgently needed; a central facility for radiocarbon date collation and distribution is needed, and Siberian material must be included in future data bases; and thermoluminescence dating should be regarded as still experimental, and funding agencies should be aware that more support is needed to develop this method.

There was considerable student participation. Seven undergraduates attended a field school at Gold Hill, various graduate students worked closely with the Soviets, and seven graduates and undergraduates attended the workshop meeting, with two presenting papers.





*Coring on Grande Elikchan Lake, April 1991.*

## *U.S.-U.S.S.R. Beringian Paleoclimate Research*

As a continuation of an existing paleoclimate program (see *Arctic Research of the United States*, Fall 1990, p. 86), a working meeting on "Late Quaternary Paleoclimates of Beringia" was convened in January 1991 at the Quaternary Research Center in Seattle. The topics of discussion were a review of the results of the 1989 and 1990 field seasons in the upper Kolyma drainage (Soviet northeast) and in north-central Alaska, respectively; late-Quaternary geology of the Jack London area; problems of pollen and spore identifica-

tion; coring equipment; and future research. Invitations were issued by the Soviets to begin a new lake coring project in the northern Urals and for additional spring field work. As a result, Grande Elikchan Lake, a site originally sampled during the 1989 summer field season, was resampled in the spring of 1991. The potential antiquity of this record makes it particularly valuable. The spring 1991 expedition was undertaken from a stable ice platform and a roll-jack driving device. A total of four cores from two separate basins within the lake were sampled. As with previous work, samples were divided between Soviet and American researchers. Preliminary analyses are underway.

One serious problem that has hampered the close comparison of paleovegetation and paleoclimate histories of eastern and western Beringia is the lack of lacustrine pollen records from the western side of the land bridge. This project represents an initial step towards improving this situation, and the results from the Jack London sites and upper Kolyma region are exciting. The pollen data indicate different late-Quaternary vegetation histories on the two sides of the straits, implying different regional responses to global climate changes. Our studies document that at no time over the past 20,000 years was there a single uniform "Beringian" landscape but rather that important mesoscale variations, evident today, have always characterized this region. Results from the cores provide the first continuous regional Holocene-late Pleistocene record. Of particular note are a sedge-dominated full-glacial pollen assemblage, dissimilar from other pollen spectra dating to this period, and a poplar subzone indicating a significant westward expansion of these populations during the post-glacial thermal maximum.

### *Participants included*

*P.M. Anderson and L.B. Brubaker, University of Washington; P.A. Colinvaux and W.R. Eisner, Ohio State University; D.M. Hopkins, University of Alaska; and A.V. Lozhkin, U.S.S.R. Academy of Sciences, Magadan.*

## *Federal Arctic Research Workshop*

A meeting of Federal agencies was convened in Anchorage, Alaska, March 19-21, 1991, to exchange information on current and planned Arctic research. The emphasis was on Alaskan-based research, with the majority of the 90 participants representing Federal agencies located in Anchorage, Fairbanks and Juneau. The workshop, organized by the Minerals Management Service at the request of the Interagency Arctic Research Policy Committee, was timed so that relevant information could be incorporated into the Second Biennial Revision of the Arctic Research Plan (see *Arctic Research of the United States*, Spring 1991). At

the conclusion of the workshop, which was also attended by state, public and private organizations, a public hearing was held to receive comments on the draft revision to the Arctic Research Plan. Curt McVee, Special Assistant to the Secretary of the Department of Interior, presided over the program. A Workshop Steering Committee, responsible for the organization of the meeting, consisted of representatives from the Department of Interior's Minerals Management Service (MMS), Fish and Wildlife Service (FWS), National Park Service (NPS) and U.S. Geological Survey (USGS); the Department of Commerce's National Oceanic and

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Atmospheric Administration (NOAA) and National Marine Fisheries Service (NMFS); the Department of Defense's Cold Regions Research and Engineering Laboratory (CRREL) and the Department of Health and Human Services' Centers for Disease Control (CDC).

Eleven Federal agencies presented reports. Many agencies discussed ongoing or planned programs relating to global change.

- The Department of Agriculture, both the Forest Service and the Soil Conservation Service,

reported on state-wide activities related to forest ecosystems, inventories and surveys, monitoring programs and resource management, including reindeer range programs.

- NOAA's report for the Department of Commerce covered many aspects of its satellite, fisheries, marine mammals, oceanography and marine assessments, weather service, atmospheric and oceanic research activities and programs.
- The Defense Department reports included



*ERS-1 SAR image, obtained on August 20, 1991, covering the southwest portion of Wrangel Island and the surrounding portions of the western Chukchi Sea. It shows a complex spatial distribution of ice floes with a wide range of floe sizes, with the largest floe ( $8.0 \times 1.6$  km) occurring just off the southwest tip of the island. A pronounced eddy is indicated just off the west coast of the island. Note the series of intricate open water returns just off the ice edge in the southwest corner of the image.*

both the Army and Navy. CRREL's research and engineering activities in Alaska were reported in detail, and the Corps of Engineers reported on its Alaska Coastal Data Collection Program. The Office of Naval Research program in both the western and eastern Arctic was summarized (see CEAREX article, this issue, p. 5).

- The Department of Energy discussed recent programs, including its terrestrial ecosystems and carbon dioxide programs in northern Alaska and several fossil energy activities.
- The Department of Health and Human Services reports covered the activities of the Alaska Area Indian Health Service and the Centers for Disease Control.
- The Department of Interior reported in considerable detail on its multifaceted mission-oriented programs and included presentations by the Bureau of Indian Affairs, the Bureau of Land Management, the Bureau of Mines, the Fish and Wildlife Service, the U.S. Geological Survey, the Minerals Management Service, the National Park Service and the Office of Environmental Affairs.
- The Department of Transportation provided information on its cooperative programs, including rural transportation technology, highway planning and research, and stream gauging.
- The Environmental Protection Agency presented recent results of its program on Arctic contamination resulting from atmospheric transport.
- NASA reported on a wide range of Alaska and international programs, including upper-

atmosphere and near-earth surface physics, tropospheric and stratospheric chemistry, glaciology and hydrology, and boreal ecosystem programs (see article below).

- The National Science Foundation described its overall Arctic science, engineering and education activities, totalling 227 predominantly university-based projects in 1990 and including plans for an ice-capable Arctic research vessel and the nationwide and Alaskan Long-Term Ecological Research (LTER) network.
- The Smithsonian Institution described the activities of its Arctic Studies Center, several major exhibitions and plans for Beringian archeology.

In his conclusion, the workshop chairman, Curt McVee, Special Assistant to the Secretary of Interior, stated that the workshop met its overall objective of exchanging information. Time did not allow the in-depth exploration of the many projects of interest to the participants, but the groundwork was established for future meetings and coordination efforts to address areas of mutual interest. The need to continue the workshop steering committee was suggested in order to facilitate the interchange of information and coordination among agencies working in Alaska. Future meetings might include more project personnel in addition to program managers.

A limited number of the workshop proceedings, edited by Joy Geiselman and Kathryn L. Mitchell, are available (OCS Study MMS 91-0053) from the Minerals Management Service, Alaska OCS Region, 949 E 36th Avenue, Anchorage, Alaska 99500, or through the National Technical Information Service in Springfield, Virginia.

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## *The Alaska Synthetic Aperture Radar Facility: Update*

On 24 April 1991 about 100 people gathered at the Geophysical Institute of the University of Alaska-Fairbanks to attend the celebration associated with the completion of the Alaska Synthetic Aperture Radar Facility (ASF). Speeches were made, antennas were christened, champagne was consumed and tours were given. More importantly, on the previous day, a final readiness review was carried out, and as no major problems were apparent, the facility was pronounced "ready to go." The only reservations at that time were caused by the fact that, although simulation tapes had been utilized extensively, it had been impossible to adequately test the end-to-end functioning of the ASF system. That required real CP-band SAR satellite data, a product that would only exist after launch.

ERS-1 was first scheduled for launch in December 1990, a date that slipped to April and finally to July 1991 because of a problem with the third stage of the Ariane launch vehicle. Fortunately the problem was located and resolved, resulting in a successful launch on 16 July. After the satellite achieved a stable orbit, the antennas and solar panels were deployed and shown to be functioning correctly. The remote sensing package was successfully tested, and the first SAR data were downlinked to ASF on 7 August.

During the following three months the satellite system and its products underwent a period of calibration. As might be expected, a number of problems surfaced, ranging from difficulties associated with the intricacies of the image-formation process to ones associated with the electronic communi-



*To be placed on the ASF mailing list, contact Cindy Wilson, ASF/GI, University of Alaska-Fairbanks, Fairbanks, AK 99775-0800.*

cation lines between ASF and the European Space Agency (ESA). One by one these problems have been resolved through the cooperative efforts of the ASF, JPL and ESA engineers. This allowed ASF to start processing data for the record on 22 October. However, ESA has not yet authorized any ground station to release data to the scientific community. We are not certain when this authorization will be given, but based on ESA's prior planning, we expect it will occur in the very near future, certainly by the end of December, when the orbit will be changed. By the end of October, ASF had received slightly over 46 hours of data over an 82-day period amounting to an average rate of 34.1 minutes per day. At 4.5 images per minute, this amounts to roughly 12,586 images, each 100 × 100 km. However, during the first 72 days, we were involved in calibration activities and were not processing for the record, resulting in a 11,205-image backlog. Now that ASF has moved into the image production mode, one might think that this backlog would start to disappear. This is not the case. Although we are processing approximately 15 minutes of data per day (well in excess of the maximum of 10 minutes of ERS-1 data per day that ASF was expected to receive), during November we have been receiving over 50 minutes of data per day. These are hardly numbers that will lead to the elimination of backlogged data.

Among the science community, no one is complaining. We have never met a scientist who was not delighted with too much data. Nevertheless, from an operational point of view, ASF has a processing problem. There are a number of steps that can be taken to lessen processing time, and these steps are being implemented. Unfortunately, even with these improvements, we do not anticipate that the processing backlog will vanish in the foreseeable future. These difficulties will, of course, be compounded by the impending launch of JERS-1 in February 1992. Scientists can console themselves with the fact that, although ASF is sitting in a processing hole, the hole is a scientific gold mine.

The ASF science program appears to be in good shape, involving a highly varied group of investigators from 11 universities, 8 governmental organizations and 6 private groups. At start-up there will be 50 projects, involving roughly 62 principal or co-principal investigators. These projects have been selected under three programs: a NASA Announcement of Opportunity (AO) and two Europe-

an Space Agency initiatives, termed PIPOR (Programme for International Polar Ocean Research) and ALASKA (Arctic Lands and Seas: Key Assessments). The disciplinary groupings and the numbers of research programs are as follows: sea ice and polar oceanography (25), glaciology (4), hydrology (4), geology (5), permafrost (1), forestry and ecology (2), calibration and validation (3) and application demonstrations (6). The emphasis on polar oceanography and sea ice is a result of the fact that SAR is a particularly powerful tool in studies of the polar oceans, as its function is not limited by either darkness or clouds, neither of which is in short supply in the polar regions. Also, the global importance of processes unique to the polar oceans is becoming increasingly apparent, resulting in enhanced scientific interest in these problems in particular and the region in general.

One interesting aspect of the ASF program is the attempt to develop automated geophysical processing capabilities via a Geophysical Processor System (GPS) that speeds the extraction of scientifically useful information from the images. After an initial period of validation and calibration, ASF will be able to provide three such products: a vector field characterizing the motion of the ice pack, a classification of the ice types and their respective areas, and a contoured spectrum of the waves in both the open ocean and the marginal ice zone. During the first years of the ASF program, considerable attention will be given to verifying and fine-tuning these products and to developing additional capabilities. We suspect that the ice-classification product will prove to be the most demanding in that it requires both a very precise cross-track calibration of the imagery and a thorough understanding of the changes in radar backscatter with season.

The ASF and the National Snow and Ice Data Center located at the University of Colorado in Boulder have formed a joint advisory group chaired by Koni Steffen and comprising ten members (five nominated by each organization). This committee, which is named the Polar DAAC Advisory Group or PoDAG, where DAAC stands for Distributed Active Archive Center, has the task of keeping both ASF and NSIDC pulling in the same direction and responsive to the needs of the polar science community. The first PoDAG meeting occurred at ASF during the Users Group meeting on 29 July 1991. More details on the results of the meeting can be found in the ASF Newsletter.

# Alaska Science and Technology Foundation

The Alaska Science and Technology Foundation was founded in 1988 with a \$6 million appropriation (see *Arctic Research of the United States*, Spring 1989, p. 34, and Fall 1989, p. 67). The first 30 grant awards made by the Foundation were list-

ed in *Arctic Research of the United States* in the Fall 1990 issue (p. 54). Listed below are the next 14 awards. The *ASTF Newsletter* is available from ASTF, 550 W. 7th Avenue, Suite 360, Anchorage, Alaska 99501-3555.

Project	Description	Alaska Benefits	Awarded/ Term	ASTF Funds	Matching Support	Total Support
<b>31. High-Efficiency Methane Generator</b> Robert L. Crosby, Jr., Borealis Systems, Inc. Eagle River, Alaska	Develop and test a high-efficiency methane digester module. It will digest waste materials, using high-temperature bacteria, to produce methane gas for power generation or heating. It represents the central energy system for a potential greenhouse/waste treatment facility.	The methane produced from organic wastes can be used to generate electricity, heat, light and carbon dioxide for enhanced plant growth in a greenhouse or controlled environment. The energy source is the focus of this project, however, and would have many heating, electricity generation and/or waste disposal applications in remote areas if successful.	1990 12 months	55,310	57,970	113,280
<b>32. Increase of Female Pink Salmon Returning to Hatcheries</b> William W. Smoker, Juneau Center for Fisheries and Ocean Sciences, Juneau, Alaska; Douglas Island Pink and Chum, Inc., Juneau, Alaska	Adapt existing rainbow trout techniques so that hatcheries can produce and release an excess of female salmon fry. The Alaska Department of Fish and Game is loaning fish culture equipment, and the work will be undertaken at the Gastineau Broodstock Laboratory, a research facility provided by Douglas Island Pink and Chum, Inc.	Over 3500 tons of pink salmon eggs were produced last year. These sold for more than \$3 per pound. An increase of female salmon would mean a proportionate increase in the quantity of eggs available for sale. This would result in a similarly increased value for the tens of millions of pink salmon which return to Alaska hatcheries each year.	1990 72 months	232,439	482,989	737,341
<b>33. Steel Piling Design for High-Salinity Permafrost Soils</b> William G. Nelson, University of Alaska, Anchorage, Alaska	Determine movement characteristics of loaded steel piles that have been placed in permafrost soils where there is a high salt content. Sufficient information will be developed to allow designs to maximize structural soundness without incurring the unnecessary costs of overdesign.	Along the northern and western coasts of Alaska, foundations for piers and buildings frequently are located in permafrost soils with a high salt content. This project will allow better design and construction in the vast areas of coastal Alaska where structures need to be built in permafrost areas in or near salt water.	1990 12 months	82,500	42,565	125,065
<b>34. Treatment of Icy Roads Without the Use of Salt</b> Dino Talavera, D&E Excavating, Wasilla, Alaska	Field and laboratory testing of newly patented system of storing sand without salt for use in winter sanding applications. Both the Alaska Department of Transportation and the Municipality of Anchorage are participating in the testing program.	Currently salt is imported and mixed with sand for application to roadways and runways in the winter. Elimination or reduction of the need for salt will have an economic benefit to the responsible government entities. More importantly, it promises to decrease the massive damage now being done by salt to roads, vehicles, bridges and the environment.	1990 10 months	88,702	32,469	121,171
<b>35. Electric Generator Protection System</b> Tim Newton, Spectra-Lab, Anchorage, Alaska	Evaluate and refine a highly sophisticated protective instrument for use in the electric utility industry. This digital relay integrates many functions now available separately at much greater expense. It also offers valuable new protective features which are presently impractical or too expensive to provide.	This instrument has the potential of being at the technical and economic forefronts of the generator protection industry. The advanced features it provides will not only benefit Alaskan utilities; indications are that its state-of-the-art functions will provide the opportunity for a new Alaskan business which will be competitive in a worldwide market.	1990 22 months	293,743	277,680	571,423



Project	Description	Alaska Benefits	Awarded/ Term	ASTF Funds	Matching Support	Total Support
<b>36. Real-Time Oceanographic Monitoring of Pink Salmon</b> Robert T. Cooley, School of Fisheries and Ocean Sciences, University of Alaska—Fairbanks, Alaska	Study the effects of seasonal and annual variation in surface ocean temperatures in Prince William Sound on the productivity of wild and hatchery-released pink salmon. Participators and contributors to the project include the Prince William Sound Aquaculture Corporation, Cordova, Alaska; Valdez Fisheries Development Association, Valdez, Alaska; and the Alaska Department of Fish and Game, Cordova, Alaska	Satellite-linked ocean buoy will provide continuous measure of upper-layer ocean temperatures and plankton blooms. Consortium study will link measurements of fry forage near hatcheries to weather events occurring over the open sound each winter and spring. Study results will improve forecasting methods and form basis for more effective management strategies for mixed-stock salmon populations.	1991 48 months	311,085*	678,361*	989,446*
<b>37. Arctic Work Pad Bioremediation Using Recirculation Leach Bed Technology</b> Michael D. Travis, Alaska Department of Transportation and Public Facilities, Fairbanks, Alaska; Cold Weather Contractors, Anchorage, Alaska	Evaluate system of using bacteria to digest petroleum for remediation of contaminated gravel work pads at Prudhoe Bay. Recirculating leach bed technology will need to be modified for application in the Arctic environment. Project includes involvement of the Alaska Department of Environmental Conservation and dissemination by the DOT&PF's Statewide Research Technology Transfer Program.	Currently Alaskans must either incinerate petroleum-contaminated soil or ship it to a treatment facility. Incineration consumes huge amounts of energy and is therefore very expensive. Shipping the material costs approximately \$400 per 55-gallon drum. Consequently many Alaskans forestall cleanups by simply piling the contaminated soil up, covering it and walking away. An economical method of remediating hazardous contamination would be advantageous to industry and the environment.	1991 11 months	17,553	42,480	60,033
<b>38. Plastic Mulch and Row Covers for Commercial Vegetable Production</b> Jerry Purser, Cooperative Extension Service, Palmer, Alaska; Ted Pyrah, Pioneer Peak Farm, Palmer, Alaska	Develop a process and document the economic feasibility of using plastic mulches, row covers and drip irrigation in commercial vegetable growing operations within Alaska.	Application of these techniques is expected to allow Alaska farmers to grow crops not currently grown commercially in the state, produce traditional crops earlier in the season to meet an earlier market, attain a higher production per acre yield, and decrease pesticide use. It will also contribute to soil, water and fertilizer conservation.	1991 12 months	16,400*	45,010*	61,410*
<b>39. Freeze Alarm and Protection Device</b> John P. Zarling, School of Engineering, University of Alaska—Fairbanks, Alaska	Develop a passive freeze protection system to reduce occurrences of burst pipes in residential and commercial buildings. This device will provide a low-cost detection and alarm system. The Alaska State Housing Authority has agreed to test the prototype system in 50 buildings it owns and manages.	Freezing of water and sewer systems in Alaska often results in extensive damage to structures and expensive repair costs. Final results of the project will be a moderately priced device which can be commercially manufactured and marketed within Alaska.	1991 27 months	96,091	64,767	160,858
<b>40. Techniques to Reduce Death Loss in Relocated Reindeer</b> Lyle Renecker, School of Agriculture and Land Resource Management, University of Alaska—Fairbanks, Alaska; Larry Davis, Reindeer Herder, Nome, Alaska	Develop appropriate techniques for air shipments of reindeer, and determine nutritional programs to adjust animals to formulated rations. Starting in 1991, reindeer will be shipped annually from the Seward Peninsula to a farm setting at Delta Junction for finishing and replacement of breed stock.	Currently an extensive reindeer ranching industry in the interior of Alaska is being developed. Study will provide the necessary shipment protocol and husbandry techniques for safe, rapid and efficient industry development. Evaluation of probiotics for stressed animals and digestive conversion of range-fed stock to formulated rations will be immediately applied in this industry. Results will also be applicable to other game-farmed species.	1991 24 months	79,876	176,208	256,084

\* Exact amounts subject to negotiation.

Project	Description	Alaska Benefits	Awarded/ Term	ASTF Funds	Matching Support	Total Support
<b>41. Birch Sap Commercialization</b> Jeff E. Weltzin, The Original Alaska Birch Syrup Company, Ester, Alaska	Develop, compile and share essential information concerning birch tree physiology as it relates to sap quality and production. Demonstrate efficient water elimination methods for birch sap using reverse osmosis technology. Work together with Marlene Cameron (project 42) to establish a cooperative of Alaska birch sugarmakers in support of the growth of this industry in Alaska.	It takes approximately 80 gallons of birch sap to make one gallon of syrup, more than twice that required for maple syrup. Project will develop and analyze factors, such as tree site, size, soil, elevation and weather conditions, influencing birch tree sap production and quality. It will also determine reverse osmosis techniques appropriate to birch sap in order to provide a more efficient water elimination method than traditional wood-fired boiling.	1991	39,050*	43,100*	82,150*
<b>42. Research and Development of a Birch Sap Products Industry</b> Marlene Carmeron, Wasilla, Alaska; Eric G. Holmberg, Department of Chemistry/Physics, University of Alaska-Anchorage, Alaska	Together with Jeff Weltzin (project 41), develop, compile and share essential information concerning birch tree physiology relating to the properties of birch sap. Develop requirements for a portable sugarhouse collection system. Determine characteristics of sugar derived from birch sap in order to develop additional commercial products.	Birch stands on public and private land in Alaska are plentiful, and birch syrup products have a ready market as specialty items which can be produced in a cottage industry setting. Barriers to product development primarily relate to the quantity and type of sugar contained in birch syrup. The goal of this project is to refine collection and water reduction techniques enough to make birch syrup and other products derived from birch syrup commercially viable, and to provide this information to potential industry participants.	1991 36 months	85,233*	104,796*	190,029*
<b>43. Development of Simplified Tests for Paralytic Shellfish Poisoning (PSP) Toxins</b> Scott T. Smiley, Institute of Arctic Biology, University of Alaska-Fairbanks, Alaska	Employ new methods using antibodies for identifying PSP toxin molecules, leading to a simple commercially feasible test. The objective is to allow development of a test which is quick, simple to use and inexpensive and which can be used in the field prior to shellfish harvest. PSP is one of the fundamental impediments to commercial shellfish operations in Alaska.	A simplified field test for the presence of PSP toxins would allow shellfish producers in Alaska to test their product before incurring the expense of harvesting and storing. It would benefit producers who culture shellfish, as well as those industries which harvest wild stocks. Advisory oversight of the project will be provided by representatives of the shellfish industry and regulatory agencies.	1991 24 months	128,537*	69,279*	197,816*
<b>44. Determine Feasibility of Using Nitrogen-Fixing Plants to Improve Forage in Delta Bison Range</b> Stephen D. Sparrow, Agriculture and Forestry Experiment Station	Assess whether select nitrogen- (N) fixing plants can be used as nutritional forage for wild and domestic ruminants in interior Alaska, if they will be palatable to wild bison, and if they can reduce fertilizer N inputs on the Delta bison range (DBR). Interior Alaska soils are notoriously N-poor and normally require fertilization to produce feed.	The DBR has only been partially successful in keeping bison out of farmers' fields during critical periods, and costs of maintaining the range are high. Additionally, a major constraint to livestock farming in Alaska is the short grazing season, forcing farmers to rely on expensive stored feed. The final product will be a specific management option for the DBR and a set of recommendations for range/pasture managers in Alaska to make effective use of N-fixing plants.	1991 36 months	55,250*	79,030*	134,280*
* Exact amounts subject to negotiation.			Totals	4,466,145	5,543,645	10,031,503

# Glacier Research Workshop

*The Steering Committee for NAGO consists of  
Carl Benson  
Geophysical Institute, University of Alaska-Fairbanks,  
Fairbanks, Alaska 99775*

*Gordon Nelson  
U.S. Geological Survey,  
Suite 201, 4230 University Drive, Anchorage, Alaska  
99508-4664*

*Matthew Sturm  
Cold Regions Research and Engineering Laboratory,  
Building 4070, Ft. Wainwright, Alaska 99703*

*Dale Taylor  
National Park Service,  
2525 Gambell St.,  
Anchorage, Alaska 99503*

*Prepared by Dale Taylor,  
National Park Service,  
Anchorage, Alaska*

A workshop on Glacier Research and Monitoring was held February 5–7, 1991, in the Anchorage, Alaska, area. The goal of the workshop was to promote cooperation and coordination between scientists involved in glacier research and land managers of national and state agencies administering public lands containing glaciers. The workshop was sponsored by the U.S. National Park Service's Global Change Program, the U.S. Geological Survey, the U.S. Army Corps of Engineers Cold Regions Research and Engineering Laboratory, and the University of Alaska's Geophysical Institute.

Invited speakers explained why glaciers should be studied and how they are studied. Panels of experts suggested critical measurements that would have to be made in a national glacier monitoring system and how to archive the data collected. Throughout the workshop, there was an active exchange of ideas and information between glaciologists and agency personnel involved in resource or land management.

Recommendations were made for a National Park Service glacier monitoring system. National parks with glaciers are well distributed and reflect major components of the world climate system. Sixteen national parks have glaciers that present research opportunities. Proposed research included mass balance measurements along a series of transects from maritime to continental climates; index measurements to allow regional extrapolations of

mass balance data; analysis of documents from Russian and other early exploration and from long-term photographic satellite series to evaluate changes in glaciers over time; and studies of the effects of glacial runoff and glacial recession on freshwater streams and salmonid production.

A permanent coordinating group [provisionally called the Coordinating Group for North American Glacier Observations (NAGO)] was recommended. NAGO's function would be to:

- Facilitate communication and dissemination of information among groups;
- Serve as a clearinghouse for coordinating glacier monitoring and research efforts;
- Recognize and ensure timely responses to special events such as glacier surges, catastrophic calving, glacier outburst floods or other hazards;
- Coordinate a national and international system for accessing archived glacier data, and facilitate cooperative activities among existing data repositories; and
- Improve the interpretation and communication of glacier research results to the public.

A steering committee has been formed to develop NAGO. The committee is interested in receiving ideas on how NAGO should function, what its goals should be and what specific interests the participating individuals, agencies and groups have. The workshop report is available from members of the committee.

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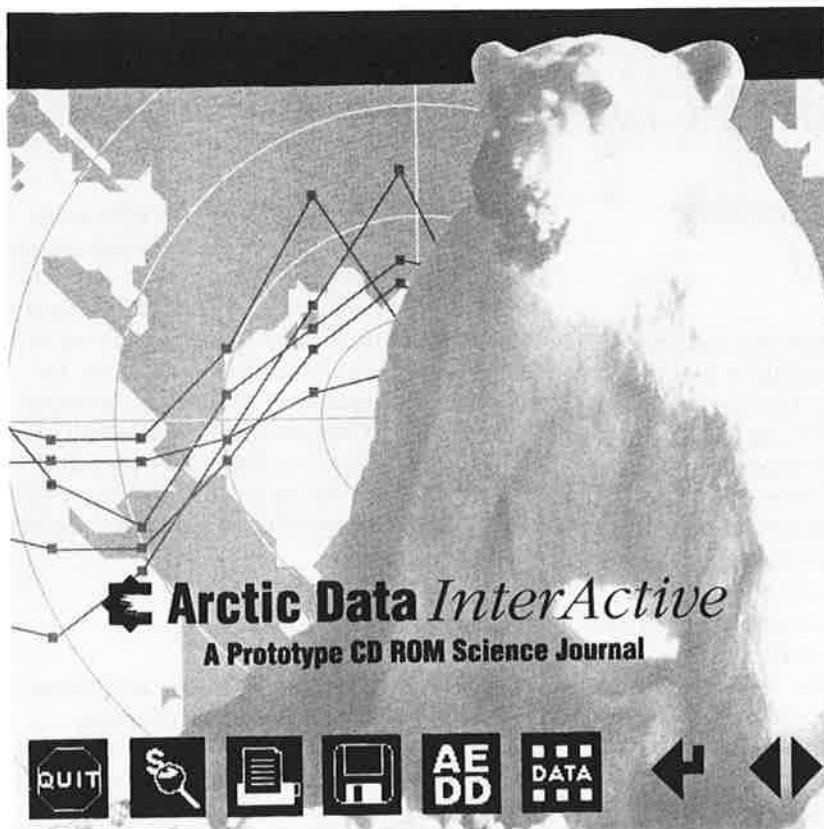
## Interagency Multimedia Data Product

The United States Geological Survey (USGS) announced the release of the first prototype of a multimedia, electronic science product. This project, published under the title *Arctic Data Interactive*, is a CD-ROM (compact disk-read only memory) multimedia publication that profoundly expands the current methods of information access and learning. Although it was designed to stimulate the way scientists and the global environmental change community communicate and exchange information, ADI is a unique model for future publications in all subjects. According to Payson Stevens, President and Creative Director of InterNetwork, Inc. (INI), the company that produced ADI, "Arctic Data Interactive is a prototype for the next generation of science journals. We're redefining the way we look at scientific publications by setting a new standard for information dissemination and navigation."

ADI is an exciting working example that lives up to the promises of CD-ROM and multimedia. Packed full of information, the disk makes it easier to access complex data. Contrary to print journals, the information becomes active, and the user can actually manipulate the data in real time. Prior to ADI this information was dispersed in publications and a variety of remote computer systems. Now scientists can make new associations with data that were previously hard to locate and often more difficult to integrate. Doug Posson, USGS Chief, Office of Field Services in the Information Systems Division, says, "The great thing about ADI is that the scientific research community can access data without incurring remote computer charges. Plus, the format allows a curious person to find what he or she is looking for and more."

Designed in a computer-generated, hypermedia format, ADI allows the user to navigate through

*For further information,  
contact Doug Posson,  
U.S. Geological Survey, Mail  
Stop 801, P.O. Box 25046,  
Denver, Colorado 80225.*



multiple layers of information in a variety of subject areas. The graphic user interface entices the user to explore sections on Global Change, Arctic Environment, Physical Oceanography, Resource Development, Sociology/Anthropology, Policy and an extensive bibliography. The disk contains complete texts of scientific journal articles, satellite imagery, data sets, image-processing software and animations. This wealth of information and range of media allow users to delve into subjects at their own interest level and depth.

USGS Project Chief Denise Wiltshire notes, "The Arctic was chosen because climate models suggest that it serves as an early warning system in response to global environmental change." Hence, ADI's content is of significance to educators, public interest groups and policy makers, as well as the general public.

A significant facet of the ADI prototype is the interagency support it received. The project was backed by 13 science agencies. Because of the interagency involvement, ADI presents an interdisciplinary approach to science. As Wiltshire points out, "We're getting to the point where it's difficult for science to keep up with technology and the volume of scientific information out there. ADI puts science in sync with technology and creates a balance between the two."

It is being distributed to more than 500 researchers and policy makers throughout the United States and internationally. The prototype was designed on the Apple Macintosh by INI, with an MS-DOS version developed by the USGS.

ADI opens the doors to communicating complex scientific data, and although it was developed for the scientific and global environmental change community, the format lets ADI reach beyond those disciplines. People with varied backgrounds can access the information, but most importantly ADI serves as a catalyst to stimulate thinking about publications of the future. "It's exciting to see people navigate through ADI and watch them become empowered by learning. They're more apt to take the information and data, make new associations, and gain real knowledge," says Stevens.

The ADI prototype will be of interest to those involved in science, education, global change or the design of information using multimedia. Slides from ADI and more information about InterNetwork are available upon request.

# Arctic Research Commission

## Twenty-Fourth Meeting August 5–6, 1991

### *Members Present:*

Donald O'Dowd,  
Chairperson; John Steele,  
Vice Chairperson; Ben  
Gerwick; Oliver Leavitt;  
Elmer Rasmuson; and  
Walter Massey (Ex-Officio).  
Staff: Philip Johnson,  
Executive Director; and  
Lyle Perrigo.  
Commission Advisory Group:  
Tom Albert; George Newton;  
Walter Parker; and Luis  
Proenza.

Visitors: Jacob Adams, Arctic  
Slope Regional Corporation;  
Sheldon Adams, North Slope  
Borough (NSB), Planning De-  
partment; Johnny L. Aiken,  
NSB; Tom Albert, NSB, De-  
partment of Wildlife Manage-  
ment; Flossie Andersen, NSB,  
Arctic Education Foundation;  
Ralph Andersen, NSB, Office  
of the Mayor; Arnold Brower,  
Jr., NSB/INVB; Charles Brow-  
er, NSB, Wildlife Management  
Department; Eugene Brower,  
Barrow Whaling Captains  
Association; Ronald H.  
Brower Sr., Ukpeagvik  
Inupiat Corporation; Ray-  
mond Bye, National Science  
Foundation; Michael O.  
Dedegan, Citizen of Barrow;  
Don Edres, NOAA/CMDL;  
Kurt Fredriksson, Alaska De-  
partment of Environmental  
Conservation; Dave Garman,  
Office of Senator Murkowski;  
Kathleen Garrison, NSB Vet  
Clinic/PHO; Jana Harcharek,  
NSB Commission on Inupiat  
History, Culture & Language;  
Robert Harcharek, NSB  
Economic Planner; Jennifer  
Chang Harty, Arctic Sivu-  
mun Iilisagvik College; Bob  
Higgins, Smithsonian Institu-  
tion; Jerry Imm, Environ-  
mental Studies, Alaska OCS  
Region; Leslie Kaleak Sr.,  
Mayor, NSB; John Kelley,  
UAF and NSB Science Advi-  
sory Committee; Tom Leavitt,

The Arctic Research Commission held its meeting at the UIC–NARL facility in Barrow, Alaska, on August 5–6, 1991. Chairman O'Dowd summarized activities since the last meeting, including appointment of a new Chairman (Donald O'Dowd) to a term ending February 1995, appointment of a new member (Clifford Groh, Sr.) to a term ending July 1995, and reappointment of an existing member (Ben Gerwick) through February 1992. Two background reports were prepared and published: Report Number 3 is Dr. Roederer's report on the state of Soviet science, and Report Number 4 is the Commission's testimony before the U.S. Senate Committee on Commerce, Science and Transportation in April 1991. This was the first Congressional hearing on Arctic research in seven years. Comparable presentations were provided by the Interagency Arctic Research Policy Committee, the Arctic Research Consortium of the United States and the Polar Research Board. Dr. O'Dowd observed that the Congressional hearing and two bills intended, among other things, to increase support for Arctic research were encouraging indicators of Congressional interest.

Dr. O'Dowd reported that since his appointment he had visited Dartmouth College and the Cold Regions Research and Engineering Laboratory in New Hampshire and had discussed research needs and opportunities with university and business leaders in Anchorage and Fairbanks. He noted that the Commission's previous Arctic research recommendations and priorities seemed appropriate for the nation; however, there was need to follow up on many of these recommendations. Elmer Rasmuson observed that there had been little response to the Commission's recommendations on Arctic health, although the scope of the Arctic Investigations Laboratory (CDC) in Anchorage has been expanded. It was decided to explore further implementation of recommendations in Arctic health research.

### *Alaska Congressional Delegation*

Senator Frank Murkowski briefly identified legislation in the Congress that would open the

Arctic National Wildlife Refuge (ANWR) to oil and gas development as a part of a national energy program. He acknowledged that science and technology in the oil industry is reducing the necessary future footprint on the land by lessons learned in Prudhoe Bay. He is concerned that Canadian opposition to development of ANWR may be based more on potential lost petroleum sales to the U.S. than on alleged impact on Native lifestyles. The Senator also stated that he found an imbalance in the government's expenditures in the Arctic versus the Antarctic.

### *Alaska Governor's Office*

Luis Proenza, Governor's Advisor for Science and Technology Policy, stated that Governor Hickel advocates Arctic research and development and is working to establish a Northern Forum with offices in Anchorage.

### *Interagency Arctic Research Policy Committee (IARPC)*

Walter Massey, Chairperson, indicated that he was the first Chair of IARPC to visit Arctic Alaska. Dr. Massey chaired his first IARPC meeting in June at which the second revision of the U.S. Arctic Research Plan was approved. The Plan was sent to the President in July and was printed in the Spring 1991 issue of the journal *Arctic Research of the United States*. Working groups are preparing implementation steps for interagency programs identified in the Plan.

Dr. Massey noted the recent production of a CD-ROM disk containing a bibliographic data base called Polar-Pac and an Arctic data directory called Arctic Data Interactive.

### *Arctic Research Consortium of the U.S. (ARCUS)*

Laura Lee McCauley, Executive Director of the consortium of 18 member universities in 15 states, presented a description of the organization's vision, members, purpose and goals. A number of activities have been completed to help define Arctic research activities relevant to global change. A set of Arctic education activities for ARCUS is be-



NSB Planning Department; Laura Lee McCauley, ARCUS; Ken Linderman, Alaska Clean Seas; Tom Lohman, NSB Planning; Donald Long, Citizen of Barrow; Marjorie MacFarland, National Science Foundation; Moy Toleum, Language & Culture; Frank Murkowski, United States Senator; Benjamin P. Nageak, NSB, Wildlife Management Department; Will Nelson, University of Alaska-Anchorage; Nate Olemaun, Native Villager of Barrow; Raynita Opie, NSB, Wildlife Management Department; Steven B. Porter, ARCO; Dee Ritchie, Bureau of Land Management; F.P. Simmonds, NSB, Housing Department; Morgan Solomons, Citizen of Barrow; Menghua Wei, National Science Foundation of China; Peter Wilkniss, National Science Foundation; Emily I. Wilson; Theodore R. Woodruff, Barrow Sun; Tom Shirley, University of Alaska-Fairbanks

ing identified. An invitation to meet jointly with the Polar Research Board, ARCUS and the Commission in March in Washington, D.C., was accepted.

## *Status of International Activities*

The first Council meeting of the International Arctic Science Committee (IASC) was held in Oslo in January 1991. Among the significant accomplishments, the Council admitted six additional countries to membership (France, Germany, Japan, the Netherlands, Poland and the United Kingdom); appointed a Working Group on Global Climate change in the Arctic chaired by Gunter Weller; agreed that research in Arctic human, social and medical sciences is needed and merits further evaluation; established an ad hoc group to consider compilation of an annotated directory of Arctic data bases and systems; considered an inventory of major Arctic scientific activities; encouraged a productive relationship between IASC and the Arctic Environmental Protection Strategy; and recommended selection of Odd Rogne to serve as Executive Secretary of IASC. The next Council Meeting is scheduled for April 27-May 1, 1992, in Iceland.

The PRB invited suggestions from the Commission on means of linking domestic and international programs through IASC and on criteria for selecting science programs for IASC. Upon discussion it was decided that the staff would draft possible recommendations for the Commission's review.

Phil Johnson reported that an Arctic Environmental Protection Strategy was signed on June 14, 1991, by the eight Arctic governments, based on working sessions over the preceding 22 months. The agreement consists of objectives and principles; state-of-the-Arctic-environment reports organized around six pollutants (chlorinated organics, heavy metals, oil, radioactivity, acids and noise); and actions to be undertaken including an Arctic Monitoring and Assessment Program (AMAP). Cooperation for emergency response to international pollution and an exchange of information on Arctic flora and fauna were also included in the Strategy. Continued cooperation in the Arctic is intended. The next ministerial meeting will be held in Greenland in 1993.

## *Discussion of Arctic Energy Development Activities*

The Commission noted the progress and uncertainties of Congressional legislation affecting Arctic

energy development as presented by Senator Murkowski and Oliver Leavitt. Mr. Leavitt observed that during the development of Prudhoe and adjacent oil fields we have learned enough to manage exploration and production on land, but offshore activities have large uncertainties in the Arctic, particularly from potential oil spills.

Will Nelson presented a discussion of needed research on marine oil spills and their control. As this issue has been before the Commission and was repeatedly emphasized in the public session, the Commission's discussion led to a decision to carefully scope a research agenda on "Oil Spill Prevention, Containment and Cleanup" using advisors and other experts to develop needed topics and criteria for final field testing.

Discussion of other areas of research related to Arctic energy development concluded that events associated with ANWR have become largely political and of limited influence by research that the Commission might now recommend.

In addition to follow-up to the Commission's EIS report, however, as Mr. Leavitt pointed out, there are very large coal deposits in western Alaska. An initial development of the Deadfall syncline with a potential of up to 750 million tons has been proposed between Point Lay and Red Dog Mine (zinc), with access to the Chukchi Sea. Research could aid the proper development of this resource.

George Newton reported on a successful meeting of Navy logistic leaders with NSF and Arctic scientists in July to explore mutually suitable cooperation. A productive discussion of Arctic science requirements versus Navy logistics capabilities identified promising opportunities.

## *Resolution of Appreciation*

The Commission adopted a formal Resolution of Appreciation to Dr. Juan G. Roederer, Professor of Physics, University of Alaska-Fairbanks, and past Chairperson of the Commission, in recognition of his distinguished services to the Commission since its establishment in 1985.

## *Public Meeting*

A public meeting was convened on August 6, 1991, to receive presentations on the needs and objectives of future research in the Arctic. About 45 people attended and 20 presentations were recorded. Also participating with the Commissioners were U.S. Senator Frank Murkowski and Walter Massey, Director of the National Science Foundation and Chairperson, Interagency Arctic Research Policy Committee.

Several major research needs were emphasized in these presentations by Arctic residents. The first was a need for credible research on oil spill prevention, containment and cleanup in ice-infested waters. Indigenous people at Barrow were concerned about potential oil pollution in the Arctic Ocean from offshore development, as well as the impacts of oil and gas development on their communities and subsistence life style. Concerns were expressed for better science in environmental impact statements, for greater involvement of stu-

dents in research, and for analysis of health implications of waste disposal activities.

### *Executive Session*

In executive session the Commission selected three additional advisors: Jerry Brown, William Nelson and Juan Roederer. John Steele was re-elected Vice Chairman of the Commission. An FY 1992 budget was approved and the Commission's conflict of interest policy was routinely reviewed.

# Forthcoming Meetings

*Listed here is a compilation of recent and forthcoming meetings, workshops and conferences on Arctic or northern topics and activities. Readers are invited to submit information on upcoming meetings, as well as reports on national or international meetings attended, to Editor, Arctic Research, National Science Foundation, Room 620, 1800 G St., NW, Washington, D.C. 20550.*

## 1991

### **Symposium on the Physics and Chemistry of Ice**

**1-6 September 1991, Sapporo, Japan**

Contact: Norikazu Maeno, Institute of Low Temperature Science, Hokkaido University, Sapporo, 060, Japan

### **3rd International Muskox Symposium**

**3-8 September 1991, Nuuk, Greenland**

Contact: Danish Polar Center, 3 Hausergrade DK-1128, Copenhagen K, Denmark  
Phone: 45-33-158666  
Fax: 45-33-134976

### **6th International Symposium on Frozen Ground**

**10-12 September 1991, Beijing, China**

Contact: ISGF91, Central Coal Mining Research Institute, Hepingli, Beijing 100013, Peoples Republic of China  
Phone: 421 4931  
Fax: 421 9234  
Telex: 22504 CCMRI CN

### **2nd WMO Operational Ice Remote Sensing Workshop**

**10-13 September 1991, Ottawa, Canada**

Contact: Ice Center Environment Canada (ICED), 373 Sussex Drive, LaSalle Academy, Block E, Ottawa K1A 0H3, Canada  
Phone: (613) 996-4214  
Fax: (613) 563-8480

### **POAC 91, 11th Conference on Port and Ocean Engineering Under Arctic Conditions**

**23-27 September, St. John's, Newfoundland**

Contact: Derek B. Muggeridge, Director, Ocean Engineering Research, Faculty of Engineering and Applied Science, Memorial University of Newfoundland, St. John's, Newfoundland A1B 3X5, Canada  
Phone: (907) 737-8804  
Fax: (907) 73704042  
Telex: 016-4101

### **Canadian Arctic Global Change Research**

**24-25 October 1991, Ottawa, Canada**  
Contact: Association of Canadian Universities for Northern Studies, 130 Albert Street, Suite 201, Ottawa, Ontario K1P 5G4, Canada  
Phone: (613) 238-3525  
Fax: (613) 238-6012

### **First International Design for Extreme Environments Assembly**

**12-15 November 1991**

Contact: IDEAA One Program Office, College of Architecture, University of Houston, 4800 Calhoun, Houston, Texas 77204-4431  
Phone: (713) 749-1181  
Fax: (713) 747-6230

## 1992

### **First Nordic Arctic Research Forum Symposium**

**6-8 January 1992, Gilleleje, Denmark**

Contact: Lise Lyde, Copenhagen Business School, Nansengade 19.5, 1366 Copenhagen, Denmark  
Phone: 33-152131  
Fax: 33-144430

### **5th International Winter Cities Biennial**

**17-21 January 1992, Montreal, Canada**

Contact: The 5th International Winter Cities Biennial, International Ideas Awards Competition, 770 rue Sherbrooke Ouest, Bureau 1100, Montreal, Quebec, Canada H3A 1G1  
Phone: (514) 872-0571  
Fax: (514) 872-9222

### **Polartech '92, International Conference on Development and Commercial Utilization of Technologies in Polar Regions**

**21-24 January 1992, Montreal, Canada**

Contact: POLARTECH '92 Secretariat, Conference Office, McGill University, 550 Sherbrooke St. W., Suite 485, Montreal, Quebec, Canada H3A 3C5,  
Phone: (514) 398-3770  
Fax: (514) 398-4854  
Telex: 05-268510

### **7th International Symposium on OKHOTSK Sea and Sea Ice**

**2-4 February 1992, Hokkaido, Japan**

Contact: OKHOTSK Sea and Cold Ocean Research Association, Monibetsu Municipal Office, Saiwai-2, Monibetsu, Hokkaido 094, Japan  
Phone: 01582-4-2111  
Fax: 01582-3-1833

### **22nd Arctic Workshop**

**5-7 March 1992, Boulder, Colorado**

Contact: John Andrews, INSTAAR, Campus Box 450, University of Colorado, Boulder, Colorado 80309-0450  
Phone: (303) 492-5183

### **Classification of Circumpolar Arctic Vegetation: An International Workshop**

**5-9 March 1992, Boulder, Colorado**

Contact: Marilyn Walker, INSTAAR, Campus Box 450, Boulder, Colorado 80309-0450  
Phone: (303) 492-5276

### **Role of Global Change in the Arctic**

**21-26 April 1992, Reykjavik, Iceland**

Contact: International Arctic Science Committee, Secretariat, P.O. Box 158, 1330 Oslo Airport, Norway  
Phone: 47-2-123 650  
Fax: 47-2-122 635  
Telex: 74745 POLARN

**14th Polar Libraries Colloquy—International  
Sharing of Polar Information Resources  
3–8 May 1992, Columbus, Ohio**

Contact: Lynn Lay, Byrd Polar Research Center, The Ohio State University, 125 South Oval Mall, Columbus, Ohio 43210-1308  
Phone: (614) 292-6715  
Fax: (614) 292-4697  
OMNET: BYRD.POLAR

**Second Circumpolar Symposium on Remote Sensing  
of Arctic Environments**

**4–6 May 1992, Tromsø, Norway**

Contact: The Roald Amundsen Centre for Arctic Research, University of Tromsø, N-9000 Tromsø, Norway  
Phone: +47 83 45 240  
Fax: +47 83 80 705

**The Impacts of Climate Change on Resource  
Management of the North**

**12–14 May 1992, Whitehorse, Yukon Territories,  
Canada**

U.S. Contact: William Bolhofer, NOAA, 1825 Connecticut Avenue, Washington, D.C. 20235  
Phone: (202) 606-4360  
Fax: (202) 606-4355

**Symposium on Remote Sensing in Glaciology III  
17–22 May 1992, Boulder, Colorado**

Contact: Secretary General, International Glaciological Society, Lensfield Road, Cambridge CB2 1ER, United Kingdom  
Phone: +223 355974  
Fax: +233 336543

**Fish Ecology in Arctic North America  
19–21 May 1992, Fairbanks, Alaska**

Contact: Sharon Oren, Conferences and Special Events, University of Alaska, Fairbanks, Alaska 99775-0540  
Phone: (907) 474-7800  
Fax: (907) 474-5592

**Symposium on the State of the Environment and  
Its Monitoring in Northern Fennoscandia  
and the Kola Peninsula**

**8–10 June 1992, Rovaniemi, Finland**

Contact: Raija Kivalahti, Arctic Center, University of Lapland, P.O. Box 122, 96101 Rovaniemi, Finland  
Phone: (60) 324 278  
Fax: (60) 324 270

**Second (1992) International Offshore and Polar  
Engineering Conference**

**14–19 June 1992, San Francisco, California, U.S.A.**

Contact: ISOPE-92, P.O. Box 1107, Golden, Colorado 80402-1107  
Phone: (303) 273-3673  
Fax: (303) 420-3760

**BOSS 92—International Conference on Behaviour  
of Offshore Structures**

**7–10 July 1992, Imperial College, London**

Contact: BOSS 92 Secretariat, BPP Technical Services Ltd., 2 Tavistock Place, London, WC1H 9RA, England  
Phone: 071-837-6362  
Fax: 071-837-0822

**6th Inuit Circumpolar Conference (ICC)**

**General Assembly and Elders Conference,  
“One Arctic—One Future”**

**20–24 July 1992, Inuvik and Tuktoyaktuk,  
Northwest Territories, Canada**

Contact: Peggy Jay, ICC Conference Coordinator, P.O. Box 2120, Inuvik, Northwest Territories, Canada X0E 0T0  
Phone: (403) 979-2737  
Fax: (403) 979-2135

**27th Congress of the International Geographical  
Union**

**9–14 August 1992, Washington, D.C.**

Contact: IGU Congress Secretariat, 1145 17th and M Street NW, Washington, D.C. 20036  
Phone: (202) 828-6688

**Third International Conference on Ice Technology**

**11–13 August 1992, MIT, Cambridge, Massachusetts**

Contact: Sue Owen, Conference Secretariat, Wessex Institute of Technology, Ashurst Lodge, Ashurst, Southampton SO4 2AA, United Kingdom  
Phone: 44 703 293223  
Fax: 44 703 292853

**New Perspectives in the Arctic: The Changing Role  
of the United States in the Circumpolar North**

**12–14 August 1992, University of Alaska–Fairbanks**

Contact: Elizabeth Leighton, Office of the Vice Chancellor for Research, University of Alaska, Fairbanks, Alaska 99775  
Phone: (907) 474-6634  
Fax: (907) 474-7225

**29th International Geological Congress  
24 August–3 September 1992**

Contact: Secretary General, IGC-92, P.O. Box 65, Tsukuba, Ibaraki 305, Japan  
Phone: 82-298-54-3627  
Fax: 81-298-54-3629

**9th Symposium on Northern Research Basins  
August 1992, Saskatoon, Saskatchewan, Canada**

Contact: Terry Prose, National Hydrology Research Centre, 11 Innovation Boulevard, Saskatoon, Saskatchewan S7N 3H5, Canada  
Phone: (306) 975-5737  
Fax: (306) 975-5143

**International Conference on Arctic Margins (ICAM)  
2–4 September 1992, Anchorage, Alaska**

Contact: Dennis Thurston or David Steffy, 1992 ICAM, Alaska Geological Society, P.O. Box 101288, Anchorage, Alaska 99510  
Phone: (907) 271-6545 (Thurston)  
(907) 271-6553 (Steffy)  
Fax: (907) 271-6805

**5th International Symposium on Arctic  
Air Chemistry**

**8–10 September 1992, Roskilde, Denmark**

Contact: N.Z. Heidarn/H. Flyger, National Environmental Research Institute, Frederiksborgvej 399, 4000 Roskilde, Denmark  
Phone: 46-30-1200  
Fax: 46-30-1114

**Symposium on Snow and Snow-Related Problems**  
(part of an International Forum on Snow Areas)  
**14–18 September 1992, Nagaoka, Japan**  
Contact: Secretary General, International Glaciological Society, Lensfield Road, Cambridge CB2 1ER, United Kingdom  
Phone: +223 355974  
Fax: +223 336543

**Eighth Inuit Studies Conference**  
**25–28 October 1992, Université Laval, Quebec, Canada**  
Contact: Louis-Jacque Dorais, Anthropologie, Université Laval, Quebec, Canada G1K 7P4  
Phone: (418) 656-7827  
Fax: (418) 656-3023

**First International Arctic Social Sciences Conference**  
**28–31 October 1992, Université Laval, Quebec, Canada**  
Contact: Ludger Müller-Wille, Geography, IASSA, McGill University, 805 Sherbrooke St. W, Montreal, Quebec, Canada H3A 2K6  
Phone: (514) 398-4960  
Fax: (514) 398-7437

**Third International Conference: The Role of Circumpolar Universities in Northern Development**  
**30 November–3 December 1992, Rovaniemi, Finland**  
Contact: Ms. Outi Snellman, University of Lapland, P.O. Box 122, 96101 Rovaniemi, Finland  
Phone: 60-324 208  
Fax: 60-324-207

1993

**Symposium on Arctic Resources: The Challenge of Development**  
**24–26 May 1993, Anchorage, Alaska**  
Contact: Don Blasko, Bureau of Mines, 201 E 9th Avenue, Anchorage, Alaska 99501  
Phone: (907) 271-2455  
Fax: (907) 271-3933

**VI International Conference on Permafrost**  
**5–9 July 1993, Beijing, China**  
Contact: G.D. Cheng, Lanzhou Institute of Glaciology and Geocryology, Academia Sinica, Lanzhou, China  
Phone: 26726-385  
Fax: 86 931 485 241  
Telex: 72008 IGGAS CN

**International Cryosols Tour: Classification, Correlation, and Management of Permafrost Soils**  
**18–30 July 1993, Northwest Canada and Alaska**  
Contact: John Kimble, USDA-SCS, Federal Building, Room 152, 100 Centennial Mall North, Lincoln, Nebraska 68508-3866  
Phone: (402) 437-5363  
Fax: (402) 437-5336

**Pre-Conference Field Trip, Geomorphology and Permafrost,**  
**11–22 August 1993, Yukon and Western Canadian Arctic**  
Contact: C.R. Burn, Department of Geography, University of British Columbia, Vancouver, B.C., Canada V6T 1W5

**Third International Conference on Geomorphology**  
**23–29 August 1993, Hamilton, Canada**  
(including the Binghamton Symposium on Geomorphology, 25 August 1993)  
Contact: McMaster University, Hamilton, Ontario, Canada L8S 4K1  
Phone: (416) 546-9140 ext. 4535  
Fax: (416) 546-0463  
Telex: 061-8347



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*Back Cover* Low-centered, ice-wedge polygons in the Kuparuk River delta, Alaska. (Photo courtesy of Donald Walker, University of Colorado, Boulder.)



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