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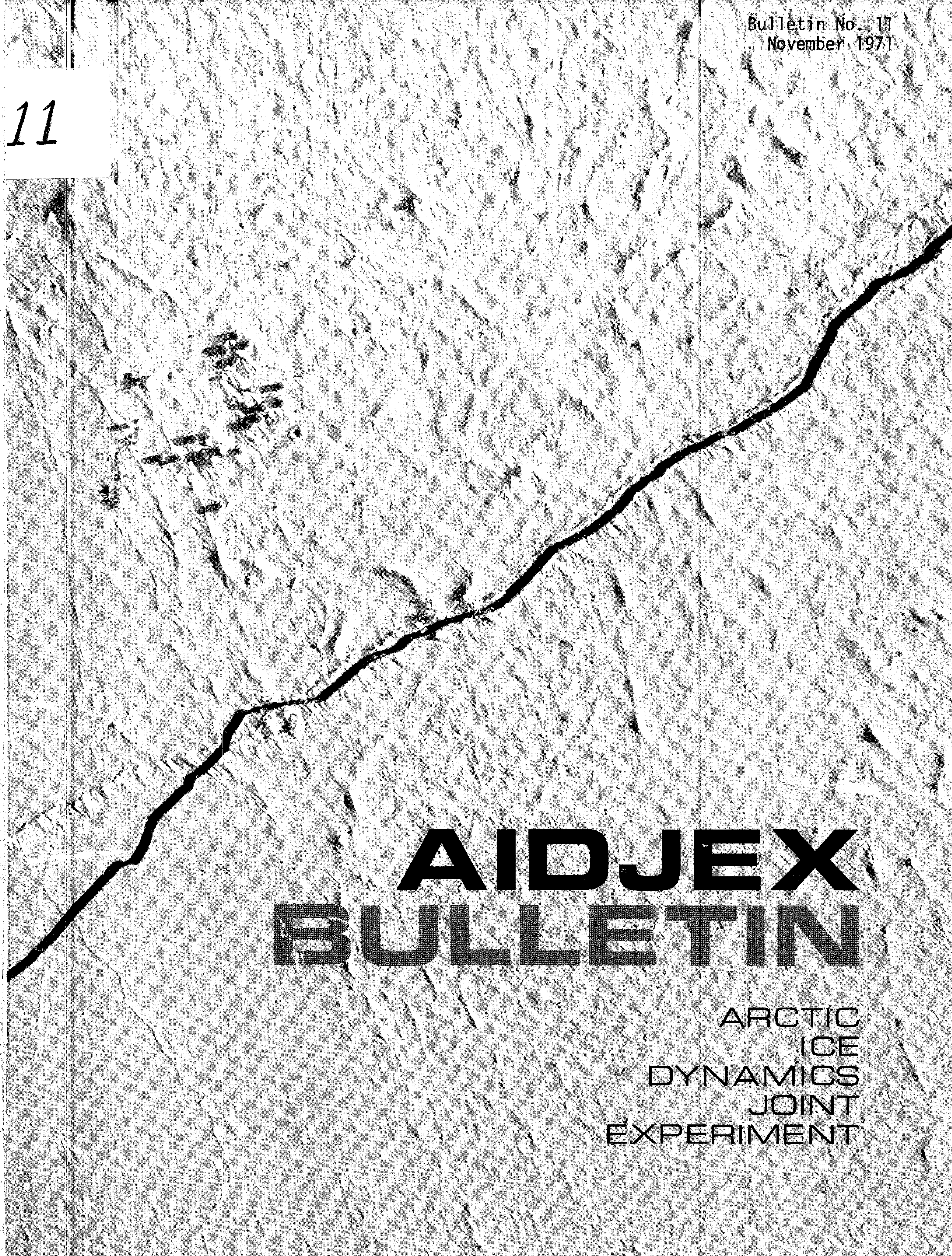

AIDJEX BULLETIN

ARCTIC
ICE
DYNAMICS
JOINT
EXPERIMENT

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TABLE OF CONTENTS

Cover: Photograph of Camp 200, site of the 1971 AIDJEX pilot study, taken during a remote-sensing flight at 3,500 ft. by the NASA 990 research aircraft Galileo. *The camera used is a Wild-Heerbrugg RC-8 metric mapping camera installed in the NASA aircraft.*

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Arctic Ice Dynamics Joint Experiment
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UNIVERSITY OF WASHINGTON

The AIDJEX Bulletin aims to provide both a forum for discussing AIDJEX problems and a source of information pertinent to all AIDJEX participants. Issues--numbered, dated, and sometimes subtitled--contain technical material closely related to AIDJEX, informal reports on theoretical and field work, translations of relevant scientific reports, and discussions of interim AIDJEX results.

Bulletin No. 11 contains translations of Russian reports on POLEX and AIDJEX, and plans for the logistics support and scientific operations of the 1972 AIDJEX pilot study.

You are encouraged to send your comments and contributions to

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PREFACE

In this Bulletin we are presenting the essence of our projected experiment in spring 1972. The logistics plan was elaborated by Rolf Bjornert and Andreas Heiberg with the help of our funding agencies and other organizations in the United States and Canada. All participants will be apprised of further details and changes as they develop.

Also, we are presenting two translations from *Problemy Arktiki i Antarktiki*, published in mid-1971 by the Arctic and Antarctic Research Institute in Leningrad. While the general scope of POLEX ranges far wider than that of AIDJEX, we are reassured by the evident complementarity of the basic approach. We hope that this will lead to expanding international cooperation in solving the many pressing problems associated with the current development of the North.

N. Untersteiner

THE POLAR EXPERIMENT

by

E. P. Borisenkov and A. F. Treshnikov

In 1968, a plan for conducting a "Natural Experiment on the Problem of the Interaction of the Ocean and Atmosphere" was published [3]. Subsequently, during the planning of the international Global Atmospheric Research Program (GARP), a decision was made to plan and conduct a complex of observations in the polar regions of the Earth as a subprogram within the framework of the main program. This subprogram was designated as "The Polar Experiment" (POLEX). In a recent work, E. K. Fedorov [4] discussed the role and the principal tasks of GARP and of its subprograms, namely "The Tropical Experiment," "The Polar Experiment," and "The Earth-Atmosphere Experiment," or, as it is designated in reference [2], "The Complex Energy Experiment."

An analysis of certain experimental data pertaining to the role of the polar regions in the formation of large-scale global processes and in the study of the processes of the interaction of the atmosphere and ocean is presented in the work of E. P. Borisenkov and A. F. Treshnikov [1].

The present article presents the scientific tasks and features of POLEX, as well as certain proposals for conducting the complex of purposefully directed observations on research vessels and drifting ice, with the aid of satellites and aircraft, using the existing meteorological and aerological network.

The principal features of POLEX are the following:

1. With a wider formulation of the task, which can be realized only through close international cooperation, POLEX should be conducted

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Problemy Arktiki i Antarktiki, No. 38, pp. 8-13, 1971. Translated (September, 1971) for AIDJEX by S. M. Olenicoff.

in two areas: the north polar and south polar regions. In the first stage, the task can be limited and POLEX conducted only in the Northern Hemisphere, where the processes directly influence the nature of the weather and of the climatic conditions over the Soviet Union and adjacent territories. Concurrently, it would be advisable to prepare a program plan for conducting POLEX in the south polar region, an undertaking which should be based on extensive international cooperation.

2. As we know, there existed several decades ago a point of view which held that the Arctic is the "weather kitchen" of the world. To obtain observation data from this region, investigations were organized during International Polar Years and through other international geophysical projects. The principal aim was the collection of data on the state of the atmosphere, without following up with specific ways to utilize these data. The present plan of POLEX calls for collecting only the data that are essential to those theoretical models of atmospheric circulation which take into account the characteristics of the polar regions.

3. An important feature of POLEX, as well as of GARP as a whole, is that it augments its study of atmospheric processes with investigations of processes in the ocean and on drifting ice to the degree that is essential for developing reliable methods of numerical long-range weather forecasting.

4. The regions encompassed by POLEX in the Northern Hemisphere are bounded by 50°N. They include vast territories of Eurasia and North America, as well as the water areas of the Arctic Basin and the northern parts of the Atlantic and the Pacific.

5. The area selected for the experiment has the following advantages:

a. The ocean-atmosphere interaction and the energy balance components in this area are characteristic of polar regions as a whole.

b. The atmospheric processes of this region exert a considerable influence on the processes of the middle latitudes.

c. The water areas are clearly confined by straits, which will make it relatively easy to determine the oceanic features of the observation system that will include the weather ships presently stationed.

d. The territories encompassed by the experiment zone have sufficient observational coverage.

e. In addition to exerting a considerable influence on the development of macroprocesses in adjacent regions, this area is of practical interest in its own right because of the intensive economic development of the Far North.

GARP is primarily concerned with the mathematical modeling of circulation processes on the basis of theoretical models, and with the conducting of natural observations to refine the various parameters entering into the theoretical models. These are also the goals and tasks of POLEX. Numerical experiments, which constitute the basis of its scientific program, will be directed toward performing the following specific tasks:

1. The development of hydrodynamic and stochastic models of atmospheric circulation, taking into account the interaction of the atmosphere and ocean in the presence of an ice cover.

2. The conducting of a series of numerical experiments taking into account the dynamics of the ice cover, which forms a nonuniform underlying surface; also, the determination of the influence of this surface on the atmospheric circulation of the high and middle latitudes.

3. The evaluation, on the basis of hydrodynamic models, of the influence of seasonal peculiarities of radiational heat influxes in the polar regions on the character of global circulation processes.

4. The investigation of the transformation mechanism of the basic energy forms in the numerical experiments, with an attempt to close the energy balance equations at each step of integrating the equations of atmospheric dynamics.

5. The mathematical modeling of the physical processes leading to the formation of inversions and stratus clouds in the Arctic in the winter

and during the period of ice-cover melting.

6. The evaluation of the role of energy flow in the ocean-atmosphere system, across the boundaries of the experiment zone, in forming the energy balance of the polar atmosphere; also, the determination of (a) the distribution of these fluxes and (b) the necessity for and feasibility of methods for taking them into account in hydrodynamic models.

7. The determination of the role of water areas in forming the energy balance of the arctic atmosphere; the justification, on this basis, of an observational system to monitor the water areas in the northern Atlantic and Pacific oceans.

8. The development of hydrodynamic models of circulation in the polar stratosphere to evaluate the influence of vertical motions and solar activity on the temperature regime of the stratosphere.

9. The investigation of the statistical structure of hydrometeorological fields, essential to mathematically model the ocean-atmosphere interaction processes on the basis of hydrodynamic and stochastic models.

10. The development of methods of dynamic objective analysis of meteorological and aerological fields for the polar zone, utilizing observation data from satellites and automatic drifting stations.

11. The evaluation of the effect of measurement error and density of the observation network on the accuracy of the hydrodynamic forecasting schemes; the advancement, on this basis, of recommendations to establish the required observational system in the polar region.

12. The analysis, on the basis of numerical models, of the possible consequences of modifying the arctic ice and altering the course of Siberian rivers (in connection with specific proposed projects).

The goal of the numerical experiments mentioned above must be (a) to make specific recommendations which take into account the characteristics of the northern polar regions in global hydrodynamic models describing atmospheric circulation and (b) to determine the role of the northern polar realm in forming the weather and climate regime of adjacent territories.

The results will be used to refine existing--and develop new--hydrodynamic and physico-statistical methods of long-range weather forecasting.

Within the framework of POLEX, it is proposed that a series of research and experimental investigations be conducted in ocean areas on research vessels and the drifting ice of the Central Arctic. The principal task of these investigations will be to more accurately define the mechanism governing the exchange of heat, moisture, and momentum between the atmosphere and ocean in the presence of an ice cover or of an intensely agitated ocean surface. The results of these investigations should help to solve such problems as:

1. The refinement of methods for calculating the turbulent fluxes of momentum, heat, and moisture above the ice for different seasons, employing modern technical means.

2. The refinement of the parameters essential to computing evaporation during ice-cover melting.

3. The investigation of the aerodynamic roughness of the sea surface in high latitudes in relation to atmospheric turbulence and wind agitation.

4. The refinement of the coefficients of wind-generated ice drift.

5. The investigation of heat transfer and evaporation from a moderately- and an intensely-agitated ocean surface under different hydrometeorological conditions in relation to turbulence and agitation.

6. The study of the effect of high humidity on the turbulent regime in the atmospheric layer adjacent to the water.

7. The investigation of the effective radiation of the underlying surface during the period of the polar night for different meteorological conditions.

For observations from research vessels, gradient measurements in the water-adjacent layer must be performed at several levels under conditions which will ensure that the setup of the instruments does not distort their readings. Simultaneously with the observations in the water-adjacent layer of the atmosphere, the turbulent pulsations in the surface-adjacent and under-ice water layers should be measured and the hydrological characteristics in the active layer of the ocean to a depth of 200 m should be determined.

The purpose of these measurements is to evaluate (a) the influence of atmospheric processes on the formation of the active layer of the ocean and (b) the influence of the dynamics of this layer on the exchange of energy, moisture, and momentum between the atmosphere and ocean.

The observational part of POLEX calls for the performance of the following series of observations:

A. ON RESEARCH VESSELS. Research vessels will be employed in the northern Atlantic and Pacific oceans, performing the following series of observations:

1. On Polygons. These investigations will study ocean-atmosphere interaction. The main body of the observations will be conducted with the aid of

a. buoys and platforms equipped with lapse-rate apparatus and a complex of instruments for gradient and direct measurements (variations) of turbulence in the surface-adjacent layer of the ocean and the water-adjacent layer of the atmosphere;

b. autonomous buoy stations equipped with photothermographs and current meters;

c. a hydroprobe equipped with temperature and salinity sensors;

d. heated thermobuoys equipped with quick-response temperature sensors;

e. attached aerostats and kite balloons equipped with the necessary apparatus for measuring the turbulence in the boundary layer;

f. infrared and microwave radiometers for measuring the temperature of the water surface and the moisture content of the atmosphere from a ship.

Concurrently, standard meteorological, actinometric, and aerological observations will be conducted on all vessels, which will also be able to directly monitor information from meteorological satellites.

Technical specifications for the new instrumentation have been prepared, and some work has begun.

2. _On Cross Sections._ These investigations aim to determine the fluxes of energy, across the southern boundary of the experiment zone, which occur in the ocean and atmosphere over the oceanic regions of the experiment. In connection with this, two standard cross sections will be performed in the northern Atlantic and Pacific oceans in specific months of different seasons. One cross section will be performed in the area of the Arctic Circle (on the east, in the region of the Bering Strait; on the west, in the region of the standard hydrological cross section). The second cross section will be performed in the Atlantic and Pacific oceans at the southern boundary of the experiment zone.

The main body of the observations will be conducted with the aid of

a. *autonomous buoy stations* equipped with photothermographs and current meters;

b. *heated thermobuoys* equipped with quick-response temperature sensors;

c. *a hydroprobe* equipped with temperature and salinity sensors;

d. *solar thermometers* for measuring the temperature of the ocean surface;

e. *microwave apparatus* for shipboard measurements of profiles of humidity and overall moisture content;

f. *standard aerological, actinometric, and meteorological apparatus;*

g. *shipboard receivers of the ART type* (for satellite observations).

Standard hydrological stations will also be taken. These investigations must run concurrently on the same cross sections in both the Atlantic and the Pacific. It is imperative that each cross section be performed with no fewer than two or three ships.

3. _On Temporary Polygons._ The indicated investigations will be conducted sporadically, their objective being

a. an investigation of oceanic water areas in zones of cyclone formation and frontogenesis zones. The main body of the measurements will be that listed under point 2, plus an expanded complex of standard meteorological and aerological observations;

b. rocket and aerological investigations of the upper atmosphere during the period of winter stratospheric warmings.

B. ON DRIFTING STATIONS. Special investigations on drifting stations will be augmented by special observations. Use will be made of the same measuring apparatus used for shipboard observations. The apparatus will be adapted for gradient measurements in the water-adjacent layer of the atmosphere and the surface-adjacent layer of the water under drifting-station conditions. In addition, a cycle of vertical-distribution measurements of ozone will be organized on one of the drifting stations.

C. AUTOMATIC DRIFTING STATIONS. Plans call for setting up 20-25 automatic drifting stations of increased reliability on the drifting ice of the Central Arctic. These stations will measure temperature, pressure, wind direction, and wind speed four times a day and will automatically transmit the data by radio. The construction of such stations is being undertaken at the Arctic and Antarctic Institute.

D. SPECIALIZED AEROLOGICAL OBSERVATIONS. The performance of these observations during the period of the experiment calls for

1. frequent soundings from research vessels using radiosondes and rockets during the period of winter stratospheric warmings;

2. in synchronism with the sounding from research vessels, frequent soundings of the atmosphere from Hays Island using radiosondes and rockets, and from the "North Pole" drifting stations using radiosondes;

3. the organization of measurements of the vertical distribution of ozone on Hays Island and on one of the drifting stations;

4. the measurement of radiation heat fluxes using actinometric radiosondes on Hays Island and on one of the drifting stations;

5. the investigation of the optical characteristics of the underlying surface and the clouds in the Arctic along a wide spectrum range using specially equipped aircraft (the Central Aerological Observatory or the Main Geophysical Observatory).

E. METEOROLOGICAL SATELLITES. During the period of POLEX, the region involved will be well covered by observation data from satellites. The satellite information will be of the following nature:

1. Data on cloudiness and departing radiation sent out by instant-readout satellites. This information will be received at the Arctic and Antarctic Institute, on research vessels equipped with readout apparatus, and at Tiksi Bay.

2. Accumulated data, including (a) the distribution of cloud and ice fields for daily day-and-night periods, (b) the distribution of total shortwave and longwave departing radiation for different parts of the spectrum, and (c) the radiation temperatures of the upper cloud boundaries, and of the water, ice, and snow surfaces.

The data listed above will be used in numerical experiments, in objective analysis studies, and in hydrodynamic precomputation models.

The bulk of the obtained information will be processed by electronic computers. In view of this, the measuring instruments will be adapted to record observation results in such a form that they can be fed directly into the electronic computers. An efficient link between the measuring system and the electronic computers will be required.

For shipboard research, a pilot project is being pursued to develop a shipboard automated system for hydrometeorological information (designated SIGMA-S, for Shipboard Information HydroMeteorological Automated System).

The Soviet POLEX proposal has been put forward as part of the overall GARP plan. The participation of organizations and institutions of the Soviet Union and other countries is very desirable. The program of POLEX can be much improved if it is augmented by the research of other nations.

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THE AMERICAN "ARCTIC ICE DYNAMICS JOINT EXPERIMENT" PROJECT

by

A. F. Treshnikov, E. P. Borisenkov,
N. A. Volkov, and E. G. Nikiforov

In recent years, an increased interest in the study of the Arctic Ocean has been noted in a number of countries bordering the Arctic. This interest has been especially strong in the USA and Canada, due to the discovery of large deposits of oil, gas, and other mineral resources in Alaska and the Canadian Arctic. One method of getting the mineral raw material to processing markets is by sea transport. For this it is necessary to make a study of ice conditions and to develop methods for their forecasting. In addition, it is presently recognized in U.S. scientific circles that the investigation of large-scale global atmospheric and oceanic processes is impossible without taking into account the influence of such powerful heat sinks of the Earth as the Arctic and Antarctic.

The economic and scientific reasons for investigating the Arctic Ocean are intertwined with military ones, which have elicited great interest on the part of the U.S. Navy. American researchers began their investigations by addressing themselves to problems of ice drift, thermodynamics of the ice cover, and the ice balance.

These problems have been studied in the Soviet Union for a long time. Following the classic works of V. V. Shuleikin and N. N. Zubov, a whole series of subsequent works were published in the USSR dealing with the thickness and solidity of the ice cover. In some of these works, ice drift is examined as one of the components of the interrelated mechanism of the ocean-ice-atmosphere system [9, 10, 12, 14, 17, and others]. For this, the forces of internal interaction were taken into

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account by means of introducing logical algorithms into the computations. Satisfactory results were obtained when empirical dependencies of ice drift on the baric gradient were introduced into the balance equations [5, 6, 7]. An interesting theoretical study of the reaction of the ice cover to external forces was published in 1967 [16].

Important results were obtained from experimental investigations performed on the drifting ice. As early as 1961, during a high-latitude air expedition, a square polygon was set up on the ice in the vicinity of the North Pole, with its sides measuring 70-75 km and a small group of observers situated at each corner. The program of the polygon investigations, continued over a period of a month, included observations of the dynamic processes in the ice cover, the atmosphere, and the upper layer of the ocean. Some of the results of this experiment are presented in [4].

In 1962, a similar polygon was set up on the ice in the vicinity of the drifting station "North Pole-10" and an analogous series of investigations was performed over a longer period of 2.5 months.

The complex of experimental observations, performed at the five station points of the polygon, included gradient meteorological and hydrological measurements which were accompanied by a recording of the drift, the shifts, the deformations, and the rotations of the ice fields, and also by aerial photographic surveys. At one of the stations, ice vibrations were measured within a seismic range and tilt investigations were also performed [8, 13].

A survey of numerical methods of investigation using a computer, carried out in recent years at the Arctic and Antarctic Institute, is presented in reference [1].

In the United States, the first attempt to work out a numerical model of mean annual ice drift in the Arctic Basin was undertaken by Campbell in 1965 [18]. He was obliged to introduce a series of assumptions due to the lack of experimental data on the internal stresses of the ice (analogous to those utilized by D. P. Laikhtman [10] for the same reasons), on the tangential friction force at the air-ice and the ice-water boundaries, etc.

In the same period a work was published by Fletcher [19], who at that time headed the polar research at the RAND Corporation.

In 1966, the RAND Corporation conducted an international scientific symposium on thermodynamic processes and atmospheric circulation in the polar zone. At that symposium, the results of research to date were presented and attention was focused on problems requiring future investigation.

It gradually became evident that the solution of the theoretical and practical problems of the interaction of the ice cover with the surrounding media is of major importance to the study of large-scale atmospheric and oceanic processes, as well as to the development of physical methods of ice forecasting.

Experience has shown that, for this purpose, observations at isolated points in the Arctic Basin are entirely insufficient and it is necessary to conduct additional experimental investigations of the dynamic processes by means of polygons set up on the ice.

The first version of the program of this experiment was prepared by Professors Untersteiner and Hunkins and was discussed at a meeting of a panel of experts of the Naval Oceanographic Office, where it was approved in principle.

Some of the scientific staff at the Arctic and Antarctic Institute had the opportunity to acquaint themselves with the above-mentioned version of the program during Fletcher's visit to Leningrad in the summer of 1969, and to offer their comments on it.

In mid-1970, at the University of Washington, Untersteiner, Maykut, and Thorndike prepared the final scientific program for the experiment to study arctic ice dynamics [20]. In preparing the program for the experiment, attention was given to the comments and suggestions of specialists from the U.S. Naval Oceanographic Office, USGS, and CRREL, as well as to those of Soviet scientists. The program of this experiment corresponds in many ways to the program of polygon investigations of ice dynamics conducted by Soviet researchers in the Arctic Basin during the period 1961-1965.

Since the program of the experiment encompasses a large complex of rather complicated physical investigations of the ice cover, which must be carefully planned and coordinated, the thoroughness with which it is being conducted is fully justified. For its fulfillment, it appears that a large number of specialists will be enlisted from various scientific institutions, while the development of specialized equipment will be delegated to different firms.

To head the experiment, a special group was created within the Oceanographic division [*ed. note*--actually, the Division of Marine Resources] of the University of Washington in Seattle. The theoretical section of the experiment is headed by Prof. Untersteiner, and the well-known polar researcher Fletcher has been asked to direct the planning and organization of the field work, which he will be undertaking as of July 1, 1970.*

As the authors understand it, the concept of the proposed experiment is as follows. Since the ice cover exerts a considerable influence on the dynamic and thermodynamic interaction of the atmosphere and ocean, it is essential to quantitatively evaluate the degree of this influence. Taking into account the fact that the Arctic ice fields are in a state of motion, which is accompanied by deformation, ridging, and appearance of ice-free areas, it is essential to study the physical mechanisms which control these processes. Thus, it is proposed that an ice polygon be selected in the Arctic Basin and a system of stations be set up on it from which detailed investigations can be carried out over a long period of time (Fig. 1).

In the center of the polygon, the establishment of a base station is proposed. Around it, at the corners of a square with 20 km sides, four automatic stations will be set up. Around this square, an additional four manned stations will be established, forming an outside square with its sides measuring 100 km. And, finally, an outer ring consisting of six automatic stations will be set up, at an initial maximum distance of separation measuring 300 km along the diagonals of a hexagon. In addition, it

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**Ed. note:* This report was written in mid-1970. On September 1, 1971, Prof. Untersteiner became the AIDJEX Coordinator and Mr. Fletcher the Director of the NSF Office of Polar Programs.

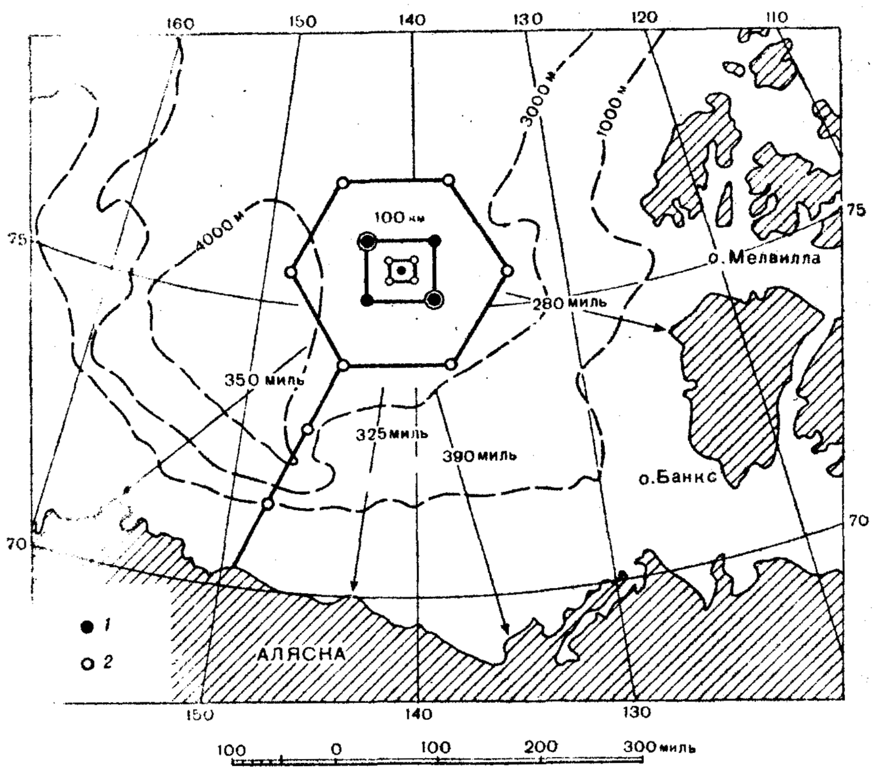

Figure 1. Arrangement of stations for the American arctic experiment on the study of ice dynamics.

1--manned stations; 2--automatic stations

is deemed desirable to establish a nearby base for logistic and technical support, preferably on an ice island. Besides standard observations, measurements of the wind and water stress will be conducted at all stations, as well as aerial photographic surveys, position measurements, recording of the sea surface slope, and studies of ice topography (both surface and under-ice).

The manned stations will function for a period of two years. During each season, selected periods will be devoted to conducting observations according to the expanded program. Preliminary research work is scheduled to begin in March 1971. The main observational work is scheduled for the 1973-1974 period. The full duration of the experiment is expected to be six years.

The following results are anticipated:

1. The measurement of the parameters relating air and water stresses to ice strain, necessary for the development of dynamic models of ice motion and, consequently, for the improvement of the quality of ice forecasts as well.

2. To obtain as much as possible of the data needed to evaluate the role of sea ice in the interaction process of the atmosphere and ocean, and in the formation of climate. In particular, it is hoped that information can be obtained about the relationship between the formation of zones of open water, the heat balance, and the production of new ice.

3. The accumulation of data on the morphology of the ice cover and the processes of its formation.

4. The investigation of processes vital to the understanding of primary production and biological phenomena in the Arctic Ocean, and the evaluation of the possible damage to the arctic environment from the continually increasing economic utilization of the region.

5. The determination of the parameters characterizing the dynamics of water masses and the conditions of sound-wave propagation within them.

6. The obtaining of the information needed to evaluate the feasibility and desirability of the artificial destruction of the Arctic ice cover.

The program also contains a discussion of certain problems which it is hoped can be formulated and solved as a result of the experiment.

The first such problem is the development of a mathematical model of ice cover dynamics. Computations show that, if the dynamic effect is eliminated, then the ice can attain an equilibrium thickness depending only on the heat exchange between the ocean, the ice, and the atmosphere. The dynamics of the ice cover greatly complicates this process.

For the development of dynamic models it is essential to know, in addition to the pressure gradient force and the Coriolis force, the friction stress between the ice and the water, and the internal ice stress.

In view of its above-stated objectives, the experiment should provide answers to the following questions:

1. How is large-scale ice deformation related to external stress fields? For this, it is essential to measure the friction force at the ice-water and ice-atmosphere surfaces, and also the components of the heat balance.

2. How is ice topography (surface and under-ice) related to the stress and strain forces acting on the ice? This will require the simultaneous solution of such problems as (a) the relationship between stress forces and the formation of cracks and (b) the influence of the dynamic regime of the ice--the presence of cracks, open leads, and pressure ridges--on the flow of heat from the ocean to the atmosphere.

3. Is the arctic ice stable or unstable?

The program of the experiment also lists the observations to be made and the instruments required for these. The sea ice observations will be conducted with the aid of aircraft (visually and by instruments), submarines, and satellites.

The equipment for these measurements must include an infrared scanner, sidelooking radar, passive microwave radar, photographic apparatus for making aerial surveys, and television apparatus of the vidicon type.

For the measurement of ice thickness, a laser system with a resolution of 1 cm will be used for measuring surface ice profiles, and submarines equipped with acoustical systems will be used for measuring under-ice profiles. For this latter purpose, the use of divers to obtain supplemental data is also proposed. The principal aim of these investigations is to find a statistical relationship between under-ice and surface topographies, thus making it possible to determine ice thickness solely on the basis of the measurable parameters of the surface topography. The complex of ice observations also includes the determination of the positions of the ice floes, the speed of their motion, and their acceleration. The relative distance within the limits of the system of stations must be determined with an accuracy of ±50 meters for the outer square and ±10 meters for the inner square.

One aircraft, equipped with radars and apparatus for aerial photographic surveying, will make flights over the region at an altitude that will enable it to cover the entire area in a short period of time. A second aircraft, equipped with laser and infrared sensors, the measurements of which are strongly dependent on the moisture content of the atmosphere, will make flights at low altitudes.

Stress measurements will be made by the profile method (indirect) and the more accurate eddy flux method (direct). For the latter type of measurements, acoustical sensors will be employed.

Direct and indirect methods will also be used for the determination of heat fluxes.

Wind direction will be recorded continuously with an allowance for ice floe rotation. Measurements will be made at all stations of incoming and outgoing short-wave and long-wave radiation, and of albedo. Atmospheric pressure will be measured with an accuracy of ±0.05 mb.

Aerological observations in the surface layer and the free atmosphere are planned.

Nonstandard oceanographic observations will include the following measurements:

a) water stress at the lower boundary of the ice, using direct and indirect methods; the first type of measurements will be made using current meters installed at depths of 0.5, 1, 2, 4, 8, 16, and 32 m;

b) form drag, using specially developed apparatus;

c) tilt of the sea surface.

All the observational results will be recorded in analog form for the monitoring of data and system performance under field conditions, and in digital form for subsequent computer processing.

The experiment will consist of four stages: planning, preliminary studies, field work, and data analysis.

At present, based on the best available information, it appears that the experiment has entered its second stage; this includes theoretical studies, the fabrication and testing of the equipment and instrumentation, and the conducting of preliminary experiments and symposiums to improve observational techniques and develop instrumentation. In the spring of 1970, a preliminary testing of methods and instrumentation was conducted on the ice 400 km north of Alaska. Over a period of a month, a group of American specialists from Washington (*sic*) headed by Coachman performed simultaneous observations of under-ice currents at stations situated at distances of 3, 10, and 20 km from one another. New sensors were also tested at the site, including an acoustic anemometer and various instruments for the continuous recording of ice strain.

Plans call for expanded investigations, using automatic and remote sensors, to be conducted on a short-term drifting station which will be set up especially for this purpose in the Arctic Basin during the spring of 1971.

In evaluating the AIDJEX program, one cannot help but note the thoroughness with which it has been worked out and the concrete steps that are being taken to advance it.

The authors of the program were entirely correct in their pinpointing of the knotty problems of ice dynamics, one of which is understanding the relationships governing the formation of ice strain under the influence of external forces. In connection with this, it is very important to develop a method for the direct measurement of ice strain and to understand the interaction between large-scale stress and strain fields.

In the tilt-measuring observations, the greatest difficulty lies in taking into account the deformation of the ice field on which the sensors are installed. These deformations occur nonuniformly and significantly distort the measurement results.

Although we give the program of the experiment a high evaluation, we feel that we must point out that the problems it seeks to solve are important, but still quite limited.

Specifically, the program in question is set up to study the characteristics of just the ice cover. The parameters of the state of the atmosphere and hydrosphere are considered as set values. In reality, however, they also vary and the ice cover plays a definite role in these variations. Thus, it would have been more logical to incorporate into the experiment a study of the mechanism of ocean-atmosphere interaction in the presence of an ice cover, with a mathematical description of its dynamic and thermal processes. The eventual development of such a model would have made it possible to simultaneously take into account not only the influence of the atmosphere on ice dynamics, but also the influence of dynamic and thermal processes in the ice cover on the state of the atmosphere, and subsequently the reverse influence of the atmosphere on the state of the ice.

But, even within the framework of the limited program as it stands, there are some insufficiently developed aspects. Specifically, its weak spot is the determination of air and water stress on the ice cover. The program provides for the sporadic determination of these characteristics at different points of the polygon. However, such information does not correspond with the objectives of the experiment. In Appendix I of the program, it is proposed that the internal strain in the ice cover be determined as a residual term from the equation of motion. This presupposes a sufficiently accurate knowledge not only of the kinematics of the ice cover, but also of the indicated stresses on it over the entire polygon. However, the sporadic determinations of the stresses at certain "characteristic" points of the polygon do not, by virtue of the statistical properties of the morphology of the upper and lower ice surfaces and the nonuniformity of external conditions (wind and currents), provide any guarantees regarding the accuracy of the field stress characteristics. Their inevitable variance will lower the accuracy of the subsequent analysis of the relationship of internal strain in the ice cover to external factors.

This problem is, of course, very complicated and its solution will require, in addition to the fulfillment of the given experiment, a whole series of theoretical and experimental investigations. However, a wider formulation of the problem corresponds more fully to the physical essence of this complicated mechanism. In connection with this, attention should be given to the program of the Polar Experiment, which was developed within the framework of the Global Atmospheric Research Program [1, 2, 3, 15]. One can say that, just as the Polar Experiment proposed by Soviet scientists and the "Tropical Experiment" are part of the GARP program, so also the American AIDJEX project can only be considered as one part, or subprogram, of the Polar Experiment.

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Mr. K. G. Sandved, Director of the NSF Polar Information Service, has informed us that his office has submitted the following items for translation under the PL 480 program:

Marshunova, M.S. and N. T. Chernigovskii. Radiation Regime of the Foreign Arctic. Leningrad, 1971. 181 p.

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Arctic and Antarctic Research Institute. Physiotechnical Investigations of Ice. Leningrad, 1971. 219 p. (Its Transactions, vol. 300.)
Table of Contents:

Peschanskii: The static pressure of ice.
Iakovlev: Method of forecasting the strength characteristics of an ice cover.
Shvaishtein: Experimental work in an ice-research laboratory.
Lavrov: The scale effect as an indicator of ice breakup mechanisms.
Petrov: Attempted zonation of the arctic sea ice according to structure.
Smirnov: Analysis of the elastic properties of a continuous ice cover by dynamic and static methods.
Afanas'ev, Dolgopolov, Shvaishtein: Ice pressure on detached pillars at sea.
Kheisin: Some transitional problems of ice-cover dynamics.
Nazintsev: The thawing of hummocked ice; Iostatic phenomena of drifting ice fields.
Fedotov: Research on antarctic ice floes.
Kozlovskii: Characteristics of the formation and structure of ice floes in Mirnyy Harbor and Alasheev Bight.
Fedotov: Radiational decay of antarctic ice floes.
Chikovskii: Supercooling sea water in nature and under lab. conditions.
Iakovlev: The destruction of ice by reactive gas jetstreams.
Shvaishtein: Cutting of ice by continuous jetstreams at high pressure.
Nikolaev: Experiment is destroying sea ice by directed detonations.
Cherepanov, Kamyshnikova: Size and form of crystals in congealed ice.
Gollandtseva, Glukhova: Investigations of sea-ice structure.
Vitko: Computing the penetrability of icebreakers through sea ice.
Smirnov, Lin'kov: Observations of fluctuations in sea-ice cover with the aid of tiltmeters.

SCIENTIFIC OPERATIONS OF THE 1972 AIDJEX PILOT STUDY

The 1972 AIDJEX field program is the most ambitious in the series of pilot studies preceding the main experiment in 1974-75. An array of three manned stations and five unmanned stations (data buoys) will be centered about 400 km north of Point Barrow, Alaska, and will provide an opportunity to test for the first time, on appropriate space scales, several elements of the design of the main experiment. Among the primary purposes of the expanded 1972 program will be the acquisition of important new data with respect to (a) meso- and macroscale ice strain, (b) geostrophic flow in the atmosphere and its relation to wind stress, and (c) geostrophic flow in the ocean. Information gathered during the 1972 pilot study will aid in planning the optimal design of the main experiment.

The Array

The array will consist of a main station and two smaller camps arranged in a triangle with sides about 100 km in length; the five data buoys will be placed on a circle of about 400 km radius centered on the main camp. The manned stations will be occupied from about 1 March until about 30 April, with the data buoy array operating for the same period. (Details of the logistics plan are given in this issue of the Bulletin.) The position of all three manned stations will be monitored throughout the experiment with leased receivers using the Navy Navigation Satellite System. An acoustic bottom referencing system will be tested at the main camp in an attempt to obtain more frequent and more precise drift data.

Atmospheric observations will be made at the manned stations using MRI mechanical weather stations and microbarographs lent by the Field Observing Facility of the National Center for Atmospheric Research. The data buoys will observe and record barometric pressure data and will, upon command, transmit this information to overflying aircraft. Oceanographic observations will also be made at the manned stations to study geostrophic flow. In addition to the general measurements taken at all the manned stations, the observational program at the main station will include air stress, water stress, radiation, heat budget, micro- and mesoscale strain measurements, acceleration, and tilt measurements. Remote-sensing ground truth observations will be coordinated with overflights by NASA and NAVOCEANO aircraft.

Scientific Program

The 1972 field study will attempt to resolve--or at least shed more light on--several fundamental scientific questions. A brief description of these efforts follows.

Strain. Simultaneous macro- and mesoscale strain measurements of high accuracy will be taken and an attempt will be made to determine correlations between them. Macroscale strain measurements will be accomplished with Navy Navigation Satellite System.[1*] A test is also planned of an acoustic bottom referencing system to determine the possibility of achieving enhanced accuracy between satellite fixes.[2] Mesoscale strain measurements will be made to an array of corner reflectors on a circle about 15 km around the main camp using both pulsed laser (accurate to 1 m) and continuous wave laser (accurate to 1 mm or less) range finders. A theodolite will be used to measure angles between the reflectors.[3] Microscale strain measurements, using bonded strain gauges, will be taken within a polygon with 1 km sides. Deformational events within the polygon will be monitored. At the same time, stress within the polygon will be measured by electric pressure gauges.[4]

Geostrophic Flow in the Ocean. Information on the mean geostrophic flow, needed for an interpretation of mean ice deformation, will be obtained from synoptic measurements of the mass field and horizontal coherence of currents

*Raised numbers refer to the list of experiments at the end of this article.

below the Ekman layer at all three stations using an STD instrument and conventional Nansen bottles.[5]

Water Stress. Determination of the optimum method of measuring water stress during the main experiment requires further investigation of the relationship of skin drag to form drag on the underside of the ice. An array of four current meter masts (one fixed and three mobile) will be used to provide detailed velocity and stress measurements around a typical pressure ridge. This information will be correlated with information on the structure of the mixed layer obtained from STD measurements.[6] In addition, currents will be measured at ten levels between 2 m and 100 m for stress measurements by logarithmic profile and Ekman layer methods, with continuous profiles of the currents in the upper layer. Profiles of temperature and salinity in the upper layer will be made with an STD instrument.[7,8]

Air Stress. An important task of the 1972 field study will be to test the possibility of deriving locally observed winds from the synoptic pressure field. Pressure measurements, taken at the three manned stations, at the five data buoys, and at existing shore stations around the Arctic Ocean, especially those near the Beaufort Sea, will be used to construct atmospheric pressure maps. Theoretical predictions of wind velocity will be compared with field measurements. Various instruments and techniques for obtaining surface winds and relating them to air stress will also be tested. A phase locked loop sonic anemometer will be used to measure shear by the eddy correlation technique and to determine the effect of pressure ridges and hummocks on boundary layer flow.[10] The results will be compared with aerodynamic estimates obtained from a single velocity profile mast using a thermal anemometer which is under development.[11] Sonic anemometers and a humidity sensor will be used to measure wind turbulence by obtaining turbulent, sensible and evaporative heat fluxes.[12] Micrometeorological profiles of wind and temperature will be taken at five levels in the first 4 m above the ice at two sites about 300 m apart.[13] In addition, twice-daily soundings will be made using the aerodynamic, balloon-supported, boundary profile system of the National Center for Atmospheric Research.[14]

Heat Budget and Radiation. To provide information on heat, mass, and momentum transfer in the atmospheric boundary layer, vertical profiles of temperature, humidity, and wind velocity will be measured in the first 2 m above the ice. Ice temperature profiles, net radiation, and shortwave albedo will be measured on pure and polluted ice surfaces.[15] In coordination with the remote-sensing aircraft flights, it is planned to observe atmospheric turbidity, the concentration of ice-crystal aerosols, and shortwave and infrared ground truth data.[16]

Remote Sensing. While final plans for remote-sensing aircraft flights are still in preparation, it is expected that both a NASA research aircraft and the NAVOCEANO Birdseye aircraft will participate. Instrumentation will include side-looking airborne radar (SLAR), laser profilers, infrared scanners, passive microwave radiometers, and cameras. The program will concentrate on tests of techniques to measure ice thickness, deformation, and other characteristics in coordination with the strain measurements.[17,18]

Ocean Tilt and Acceleration. Attempts to measure ocean tilt will be made with three instruments: a biaxial tiltmeter,[20] a hydrostatic level, and an experimental system using pressure sensors installed in the water beneath the ice.[21] An accelerometer is also under development for testing during the pilot study.[22] These efforts will be closely coordinated with the acoustic bottom referencing system, which will use an array of hydrophones at the main camp and expendable acoustic sources on the ocean bottom to provide high-frequency, small-scale positioning.[2]

ERTS and IRLS Stations. Prospects are currently being explored for testing two ERTS Data Platforms and several IRLS data transmitters. IRLS and its follow-up system TWERLE (planned by NASA for launching in summer 1974) provide the type of data acquisition and positioning capability that will be crucial during, and particularly after, the main AIDJEX effort.[23]

Although this summary of scientific acitivity is complete at the time of writing, it should be remembered that the field pilot study program is designed to test and evaluate new technology as well as advance our knowledge. It is inevitable that some adjustments will be required under these circumstances. Unforeseen and unforeseeable obstacles will arise, as will opportunities, and the planning process has to remain as flexible as possible.

PROJECTS PLANNED FOR THE 1972 AIDJEX PILOT STUDY

	Project	Principal Investigator	Institution	Funding Agency
1.	Transit Navigation	Martin/Thorndike	AIDJEX	NSF
2.	Acoustic Bottom Reference	Martin/Thorndike	AIDJEX	NSF
3.	Mesoscale Strain	Weeks	CRREL	CRREL/NSF
4.	Microscale Strain	Tabata	Inst. Low Temp. Sci.	Japan/NSF
5.	Interior Flow	Coachman	U. Wash.	ONR
6.	Boundary Layer Flow	J.D. Smith	U. Wash.	ONR
7.	Water Stress	Hunkins	Lamont	ONR
8.	Boundary Layer Measurement	Pounder	PCSP	Canada
9.	Pressure Data Analysis	Brown	AIDJEX	NSF
10.	Direct Shear Stress	Businger	U. Wash.	NSF
11.	Aerodynamic Determination of Shear Stress	Goddard	U. Calif. (Davis)	NSF
12.	Wind Turbulence Measurement	S.D. Smith/Banke	Bedford Institute	Canada
13.	Micrometeorological Profile Studies	Pounder	PCSP	Canada

	Project	Principal Investigator	Institution	Funding Agency
14.	Boundary Profile System (NCAR)	Goddard	U. Calif. (Davis)	NSF/NCAR
15.	Boundary Layer Transfer	Goddard	"	NSF
16.	Radiation Fluxes	Weller	U. Alaska	ONR
17.	Remote-sensing Over-flights (NASA)	Campbell	USGS	NASA
18.	Remote-sensing Over-flights (NAVOCEANO)	Wittmann	NAVOCEANO	NAVOCEANO
19.	Microwave Measurement of Ice Thickness	Barrington	CRC	Canada
20.	Biaxial Tiltmeter Measurement	Hunkins	Lamont	NSF
21.	Ocean Tilt	Weber	DEMR	Canada
22.	Accelerometer	Evans	U. Wash.	NSF
23.	ERTS and IRLS--tentative	(Blood)	(APL/U.Wash.)	(---)

LOGISTICS PLAN FOR THE 1972 AIDJEX PILOT STUDY

by

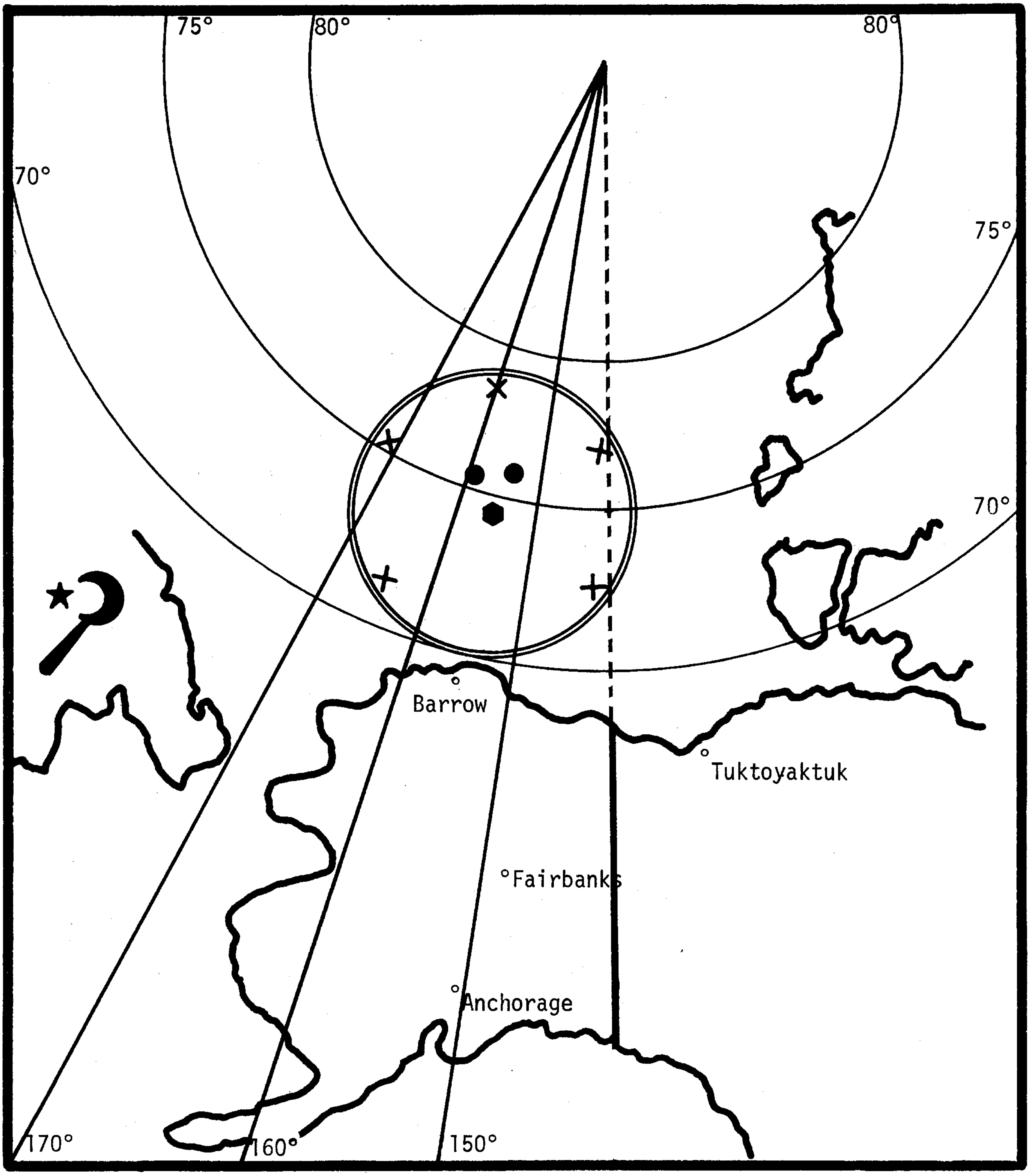
Rolf Bjornert and Andreas Heiberg
AIDJEX Logistics Coordinators

INTRODUCTION

The general outlines, and many of the specific features, of the logistics plan for the 1972 AIDJEX field program are now complete. Because of the size and complexity of the field operations, the planning for logistics support has to be completed well in advance of actual operations. The planning has been based on a careful assessment of the logistics support requests from the principal investigators who will participate in the scientific program. While some details are yet to be worked out, the general plan has been established and reviewed with the agencies which will provide funding. No requests for additional logistics support can be accommodated.

The 1972 field program will be conducted on the ice about 400 km north of Point Barrow, Alaska. Logistics support for operations will be staged through the Naval Arctic Research Laboratory at Point Barrow. It is planned to establish three manned stations: a main camp occupied by about seventy scientists and support personnel, and two satellite camps with three men each. The manned stations will be about 100 km apart in the form of a triangle. Five unmanned data stations (data buoys) will be placed in a circle with a 400 km radius around the main camp (Fig. 1).

The scientific program at the manned stations will commence about 1 March and terminate about 30 April (see "Scientific Operations" in this issue of the Bulletin). Logistics support preparations will get under way at NARL in December and expand as necessary to be ready for movement to the ice in late February.



Legend: ● Main Camp • Satellite Camp X Data Buoy

Fig. 1. Map of planned 1972 AIDJEX array.

OPERATIONS

Airlift of Equipment to Ice

Preparations for deployment will begin at NARL in December, when four field engineers (camp managers on loan from PCSP) will arrive to begin checking out and refurbishing equipment. They will also be responsible for organizing and storing equipment forwarded by principal investigators for transport to the ice. Principal investigators themselves will be responsible for ensuring that their equipment and personnel arrive at Barrow to meet the operational deadlines. A detailed operations schedule, including deadlines, will be forwarded to all participants at a later date.

Approximately 600,000 pounds of personnel, scientific gear, fuel, and support equipment will be flown to the ice from the logistics base at Barrow. The C-130 will fly two major airlifts to the main camp. The first, on about February 15, will take out all buildings, a construction crew, fuel, and support equipment; the second, on about February 26, will transport most of the scientific equipment and the first scientists. A detailed, but preliminary, list of equipment to be transported to the ice is given in Tables I and II at the end of this report. Principal investigators are being advised of adjustments which must be made in their requests for support equipment and services.

Scientific parties planning to arrive at Barrow after the main deployment to the ice are strongly urged to send their equipment in advance to permit loading on the C-130 while it is available. The R4-D which will be making weekly service flights between Barrow and the main camp will have a limited payload at the expected range and should not be relied upon to transport gear other than personal effects.

Since only limited stevedoring services are available at Barrow, principal investigators will be asked to lend certain personnel from their groups to assist in the later stages of receiving and loading equipment for movement to the ice. With this exception, it is planned that the majority of the participants will have only a brief stopover at Barrow enroute to the ice to reduce the load on facilities at NARL and to permit the most efficient use of the participants' time.

In the same vein, to assist in cargo handling and reduce the possibility of damage from cold soaking, principal investigators are asked to clearly mark boxes of equipment with their own name, weight of each box, and other pertinent information. The information should be displayed on several sides of the box. A fluorescent red spot at least six inches in diameter should be placed on all sides of boxes containing equipment which cannot withstand cold soaking.

Camp Deployment

Weather permitting, the search for the camp area (between 75°-76°N and 152°-156°W) will begin on February 7. The R4-D and the Twin Otter making the search will carry a prefabricated building, a generator, a communications radio, a radiobeacon, and a crew to set up the initial camp.

By February 15, the C-130 will have flown out all the builidngs and a construction crew consisting of seven carpenters, one electrician, and one mechanic. The C-130 will then fly out the fuel supply and support equipment that can be stored outdoors. Enough buildings should be ready and warmed up to receive the scientific groups and their instruments on February 26.

On about February 20, the Twin Otter will begin to deploy the two satellite camps, each located 100 km from the main camp. Then the Otter will place the five data buoys.

The main camp will consist of 30 prefabricated buildings for work and living spaces and five longhouse tents and five igloo tents for storage. The majority of the prefabricated buildings will be 12 feet by 16 feet, with a few planned which will be 12 feet by 20 feet. A cooking staff of four men will prepare and serve meals in a central dining hall. Electrical power sufficient to meet the minimum requirements of the principal investigators will be provided. A sketch of a preliminary plan for the main camp is given in Fig. 2. The level of occupancy at the main camp is illustrated in Fig. 3.

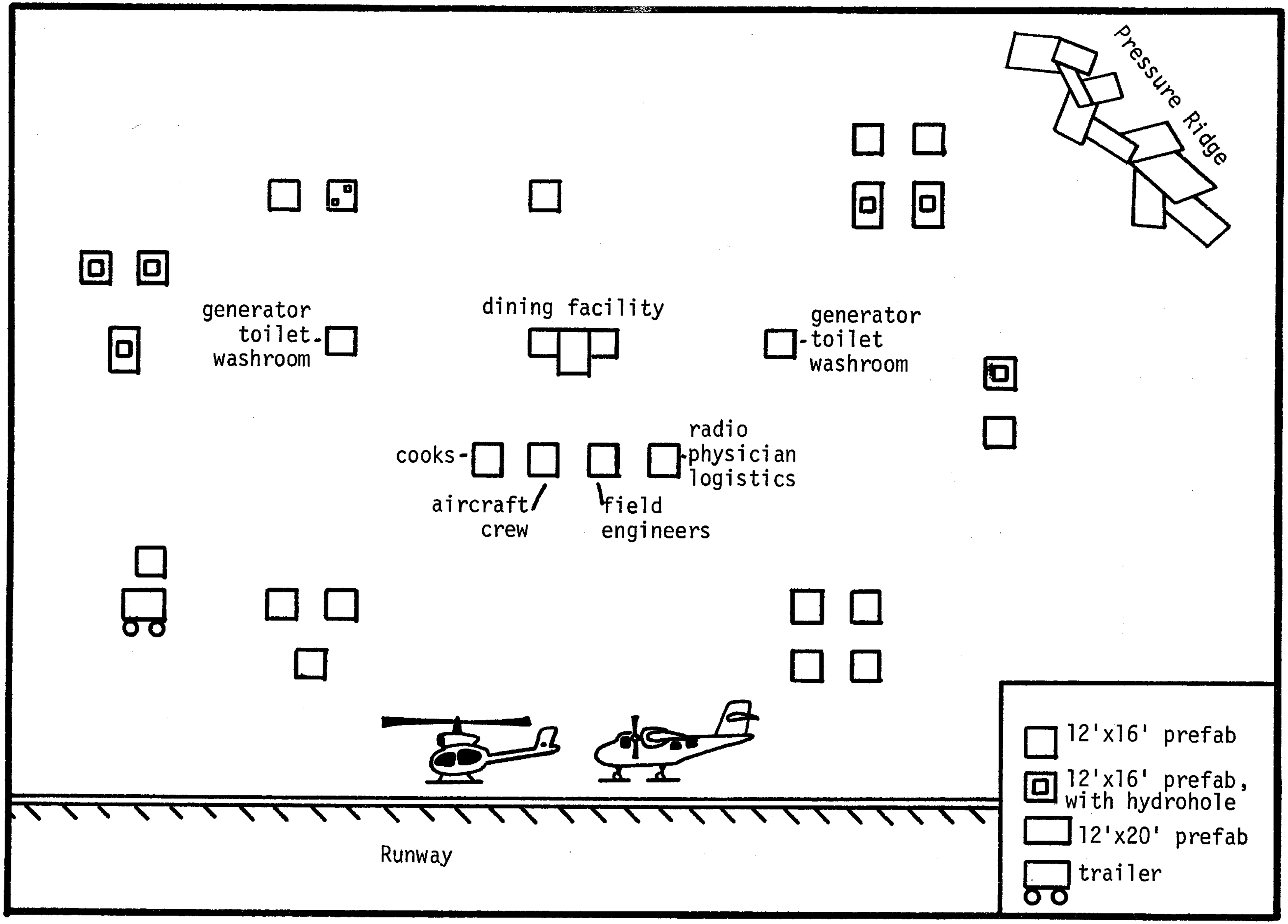


Fig. 2 . Schematic camp layout (MC).

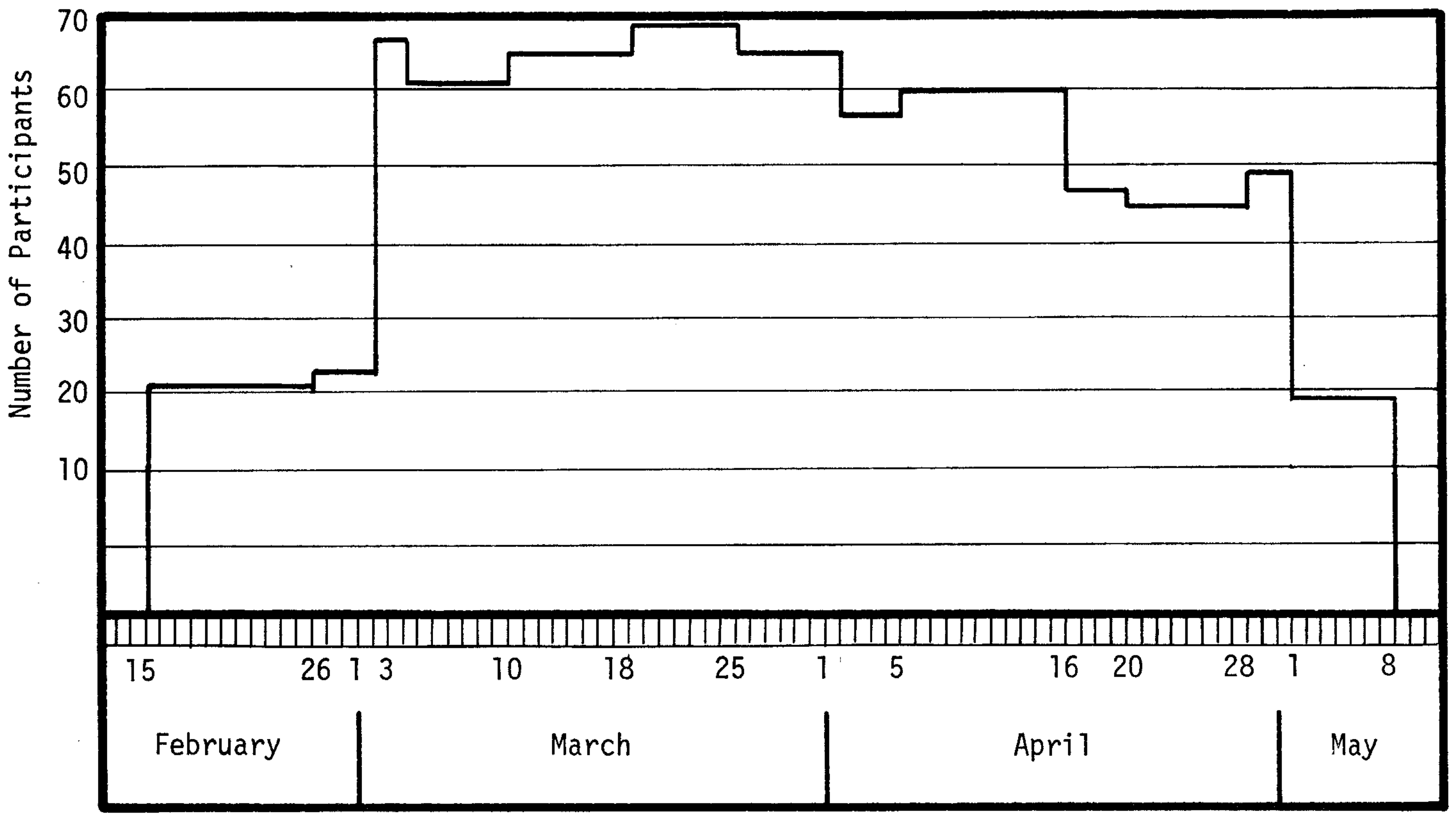


Fig. 3. Chart depicting level of occupancy of Main Camp from February 15 to May 8, 1972.

Three parcolls will provide living and working space at each satellite camp. Normally, three men will occupy the satellite camps, which can accommodate three more for short periods. Crews at the satellite camps will prepare their own food.

Service Flights

The Twin Otter will make the weekly flights necessary to service the data buoys--collect the recorded data, replace power sources, and possibly replace malfunctioning units--and will retrieve the units upon completion of the experiment.

The helicopter will fly once a week to the satellite camps from the main camp to deliver fresh food, mail, and spare parts. It will also fly the scientists to sites outside the camp area and transport, by sling, heavy items from the runway to the buildings and work areas.

The NARL R4-D airplane will handle the service flights between the logistics base at Barrow and the main camp, visiting the camp once a week to deliver spare parts, food, mail, and personnel.

Communications

The field stations will have daily radio contact with NARL at Barrow. This year there will be a greater choice of radio frequencies to increase the reliability of communications should any frequencies get blocked. The main radios will be the Collins KWM-2 transceivers, which have 100 watts PEP output power in the SSB mode. As backup for these, there will be RF-1400 transceivers, battery operated, whose output power is 20 watts PEP in the SSB mode. The Polar Continental Shelf Project will also lend a set of transceivers which are equipped with the Canadian frequencies. The main camp will have VHF radio capability for communicating with the aircraft.

A number of pocket-sized personnel-locater beacons (VHF homing transmitters) will be available. These must be checked out by everyone who leaves the general camp area and by any group deposited by helicopter at a remote site. If a white-out or bad weather prevents anyone from returning to camp, he can turn on the VHF locater beacon; the helicopter or the Twin Otter will then be able to home in and retrieve him when weather conditions permit.

Participants are encouraged to bring along pocket-sized AM transistor radios that will cover the standard broadcast band. At least one low-powered radiobeacon will transmit in this band at each camp in addition to the high-powered radiobeacon that directs the airplanes to the camps. The AM radio receiver antenna is highly directional, enabling people who walk away from the camp to find their way back if a sudden change in weather occurs.

Medical Service

A physician-surgeon will be available at the main camp to treat minor medical problems and provide emergency care for more serious injury and illness. All personnel going to the ice camps will be required to submit, prior to their departure, medical certification of the state of their health. Personnel with histories of heart, gastro-intestinal, and circulatory problems will be asked to provide additional information. A more detailed instruction on this will be issued soon.

Evacuation

The scientific activities on the ice will continue until 1 May. From then through 10 May, the C-130 will evacuate the camps. Should the original runway not be usable at this time, an alternate evacuation plan will be used. The Twin Otter and helicopter will hoist everything but expendable equipment to one of several alternate landing strips previously chosen during routine flights.

If the whole area around the camp disintegrates enough to preclude evacuation of equipment by even an alternate plan, it may be possible to go out in the summer with an icebreaker and retrieve whatever can be found. In any emergency, the safety of personnel must be the primary consideration.

A few marker devices will be left at the three camps. The buildings will not be retrieved, since the cost of evacuation and refurbishing equals their value. An interrogatable ADF beacon will be left at the main camp. An IRLS package, working with the NIMBUS navigation satellite, will be left at each of the manned stations, and an array of passive radar corner reflectors will be fixed at the stations. It is hoped that this will provide enough redundancy to be able to find the camp site again.

Table I. C-130 Air Lift from Barrow to Main Camp

* People: 64 scientists and other personnel	14,100 lb.
* Scientific gear	65,000
Living space, main camp: 12 prefabs	36,000
Working space, main camp: 12 prefabs	36,000
* Storage space, main camp: 10 longhouse tents and 3 igloo tents	1,060
Generator and toilet houses: 2 prefabs	6,000
* Living/working/storage space, satellites: 4 parcolls, igloo for generator/toilet	3,020
Food for 5627 mandays	39,400
* Generators: two 19 kw, three 6 kw, two 4 kw	7,600
* Skidoos: 3	1,200
* Sleds: 5	250
* Pulkas: 8 from PCSP	240
Explosives (Petron, Astrolite, Nitrone or equiv., caps, leads, etc.)	500
* Messing gear: trays, pots and pans, 3 ranges and 2 Coleman stoves for satellites	350
Building inventory: *15 tables	7,500
*40 chairs	150
plywood and 2x4s for benches and shelves	280
*30 double and 15 single beds with mattresses	1,000
*15 wash trays	1,825
* Toilets: 6	250
* Powerheads: 3	10
* Tools: 10 chisels, 6 picks, 5 needles, 10 shovels, 10" augers, etc.	300
* Fuel: †propane, heating: 30 bldgs x 8 wks. x 1 bottle/week/bldg. (240 bottles)	41,000
* †propane, scientific use: 9 bottles	1,550
generator fuel: 2 D311 x 56 days x 15 gal/gen/day (36 drums)	15,700
2 6 kw x 56 days x 6 gal/den/day (16 drums)	7,000
generator oil: "9170," 4 drums	1,900
Skidoo oil: "SAE 30," 5 cases	100
motor gas: 10 drums	3,600
JP4/JP5: 770 drums	335,000
* Wire, electrical, 6000 ft.	1,500
* Radios (3), beacons (3), VHF (1), 10 pocket radios, 8 locators, 10 ADF beacons	1,150
(*) Evacuate (123,335 lb.) (†) empty bottles only evacuated	630,655 lb.

Table II. Twin Otter Air Lift from Main Camp to Each Satellite

* People: 3 scientists	660 lb.
* Scientific gear	3,500
* Generator and toilet house: 1 igloo	20
* Living/working/storage space: 2 parcolls	3,000
Food: 254 mandays	1,780
* Generators: one 6 kw, one 4 kw	1,000
* Pulka: 1 from PCSP	30
Explosives (Petron, Astrolite, Nitrone or equiv., caps, leads, etc.)	100
* Messing gear: trays, pots and pans, 1 range	50
Building inventory: *3 tables	30
*4 chairs	28
plywood and 2x4s for benches and shelves	100
*3 double beds	150
*2 stoves	50
*2 wash trays	2
* Toilet: 1	10
* Tools: 1 chisel, 1 pick, 1 needle, 2 shovels	50
* Fuel: †propane, heating: 2 bldgs x 8 weeks (16 bottles)	2,720
generator fuel: 8 drums	3,500
generator oil: 1 drum	475
Skidoo oil: 1 case	20
motor gas: 2 drums	720
* Radio (1), beacon (1)	50
	18,045 lb.

(*) Evacuate (9,750 lb.) (†) Evacuate empty bottles only

SAFETY PRECAUTIONS ON THE ICE

by

N. Untersteiner
AIDJEX Coordinator

With the increasing size of our camps on the ice, we must face an increasing possibility of accidents. In spring 1972 we will, for the first time, have a resident doctor on the ice. Among the numerous potential causes of accidents, two are especially easy to control:

Explosives

R. Tripp is a licensed expert who will be responsible for the legal procurement and shipping of explosives. Since it will be impossible for him to be present at all locations where blasting is required, all individuals intending to use explosives will obtain them from him and be instructed in their use. The abundance of radio transmitters on the ice will make it necessary to use fuse for setting off charges. Electric firing devices should be used only under compelling circumstances. Detailed instructions will be prepared by Mr. Tripp.

Rifles and Pistols

Polar bears are inquisitive and fearless. The stories of unsolicited attacks on people are so well known because of their rarity. In the opinion of expert hunters, the only weapon effective against a polar bear is a rifle. Rifles will be provided to all camps and should be carried by personnel working away from camps. Bears are primarily interested in garbage dumps. If they cannot be persuaded to depart, or if they are in the process of destroying equipment, they may have to be killed. (If the equipment is already destroyed, there seems little point in trying to educate the bear.) Bears shot without a license cannot be brought back to land.

Except in the hands of the Sundance Kid, pistols are useless for protection against bears, but they are a traditional source of other troubles. While there are no strict legal regulations that would prevent individuals from bringing their handguns, we urgently request all participants to leave them at home.